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ABSTRACT

This concluding report of a project initiated by the Cogswell Polytechnical Institute entitled "The Richmond Plan," focuses on the results of a reevaluation of the principles and practices of high school programs in the Richmond City Schools in California. This project, designed to meet the specialized needs of "average" high school students in terms of higher education and to determine whether a pretechnology high school program is possible was financed by a grant from the Rosenberg Foundation of San Francisco. This pretechnical training program involved the following departments of the school functioning as a team: English, science, mathematics, drafting, and the shop areas. Contents of this report cover: (1) program administration, (2) counseling role, (3) teaching methods, (4) class analysis of the program, (5) curriculum materials, and (6) various pretechnical course outlines. It was concluded that it is possible for a community college to accept the responsibility of developing a high school preparatory program leading to semiprofessional offerings and still maintain the state and local educational requirements as demanded by state and city agencies. The cost to the district for the program, once the teachers are trained, is not significantly greater. (GR)

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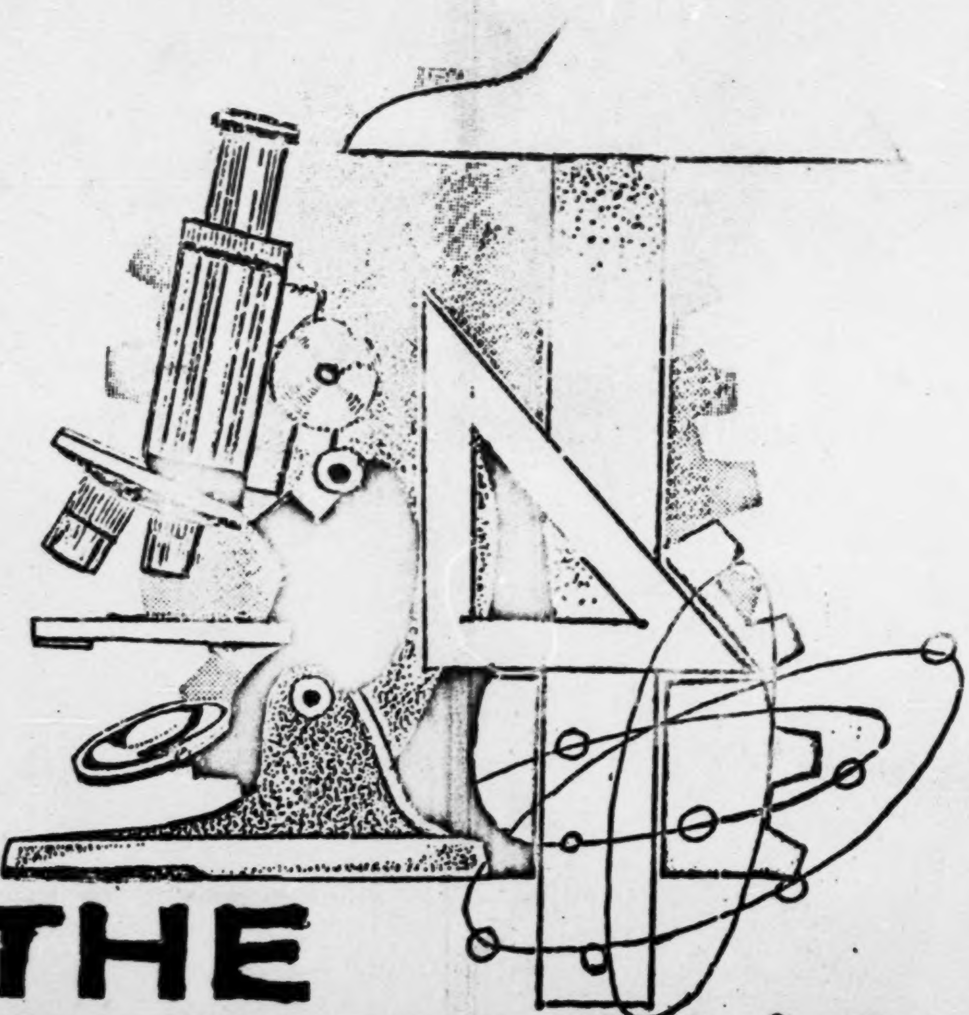

"THE RICHMOND PLAN"

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RICHMOND UNION HIGH SCHOOL DISTRICT

COGSWELL POLYTECHNICAL COLLEGE

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"THE RICHMOND PLAN"

A Report of a Pre-Technology Program for the "Average Learner."

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FOREWORD

This report of "The Richmond Plan" brings to a conclusion, the first phase of a series of projects begun by The Cogswell Polytechnical College, in 1959. Because industry in the United States has placed increasing emphasis upon technical training which requires a college education, Cogswell began a development program to assist the public in understanding and supporting technical institute education. This particular project was a major re-evaluation of the principles and practices of high school programs designed to meet the specialized needs of "average" high school students in terms of higher education; and to determine if a pre-technology high school program were possible.

The successful introduction of a pre-technology high school curriculum in the Richmond City Schools is the result of the sacrificial efforts of many people over a period of years, and was made possible by a grant from The Rosenberg Foundation of San Francisco. The Study Group is grateful for the encouragement and cooperation of Superintendent George D. Miner, and the assistance of Dr. Woodrow Snodgrass and Dr. Robert Griffin.

It is a privilege to acknowledge in behalf of Cogswell Polytechnical College and the Richmond City Schools Study Committee, the profound gratitude all of us feel toward Mrs. Jackson Chance, the Executive Director of The Rosenberg Foundation.

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PREFACE

In the period following World War II, especially since 1950, the area of interest traditionally the concern of the Technical Institute has been profoundly influenced by the surging currents of change which have swept through the nation's colleges, universities, and high schools. Advanced American technology, automation, and over-emphasis in secondary education upon university training in the liberal arts have combined to create a serious shortage of trained engineering technicians at the very time our country is facing an unemployment problem. Indeed, the repetition of pronouncements on the matter has probably dulled our sensibilities in regard to it. It is currently estimated that the demand of American industry for engineering technicians is 140,000 a year while the American school system is producing approximately 40,000 such persons a year. Additionally, a major social problem exists in the United States because of a steady decline in the number of available unskilled jobs and a steady increase in the number of unskilled high school graduates. In California, the problem is compounded by the heavy inmigration factor. It is presently estimated that approximately one million American high school graduates annually enter the job market unprepared for anything but unskilled labor. The traditional American apprenticeship system for training skilled workers is currently producing substantially less than 10% of the new industrial technicians required each year and in many cases our apprenticeship programs require the apprentice to duplicate work performed in the high school system.

In 1962, there were in excess of two million youthful job seekers. By 1970, there will be a surplus of three million, and during the next decade, some twenty-six million youth will enter the labor force for the very first time! Of this group, a minimum of 30% will be under-educated for the employment available to them. Despite this decrease in jobs resulting from automation, this same automation has created and is creating an increasing number of jobs requiring an exceptionally high degree of training and skill. It appears that our national requirement at the present time is for approximately five million highly skilled workers to maintain our technology at the present level.

The paradox of increasing numbers of highly paid job opportunities coupled with accelerating unemployment of unskilled workers is not a product of any single factor, but rather a combination of factors, namely: automation in industry, business, and particularly on the farm; a decreasing capacity of American parents to provide their children with proper guidance and training in job skills, a failure of apprenticeship system because of its high cost to business; union restriction on numbers; the inadequacy of school facilities in relationship to on-the-job conditions of employment; the tragic lowering of social status and prestige of the engineering technician, coupled with an increasingly abstract nature of college level engineering training; and the incapacity, for many reasons, of increasing numbers of school-age youngsters to assimilate training materials through traditional teaching methods.

While secondary school college preparatory programs have remained at a high level and in many areas are vastly improved (i.e. SMSG

Mathematics, CHEM study, PSSC Physics, etc.,) preparation for post high school training as engineering technicians has deteriorated in the face of changing requirements and emphasis on university preparatory programs which are unrelated to technical education.

School counselors are generally competent to discuss university education programs but are on the whole poorly informed with reference to the requirements of technical institutes. High school programs preparing students for post-graduate technical education in junior colleges are largely inadequate.

Cogswell, in cooperation with the Richmond City Schools, pioneered the pre-technology plan which is designed to develop high school programs geared to training students for various technical curriculums. Cogswell is propagandizing to change public attitudes toward technical training by emphasizing the "average learner" and encouraging enrollment of capable average high school graduates not eligible for or not thinking about university training.

While the junior college has been introduced as a means of providing terminal educational facilities in the technical institute field, the majority of such institutions are still university oriented and staffed by personnel better adjusted to university parallel work and teaching, rather than to technical institute instruction. It is gratifying to note that here in California, public school efforts to correct known deficiencies are growing daily with exceptional programs throughout our State. There are presently thirty-two Technical Institutes in the United States offering training with varying degrees of effectiveness in curriculums accredited by the Engineers Council for Professional Development.

Typical of these schools is The Cogswell Polytechnical College which was founded in San Francisco in 1887. Cogswell awards an Associate in Engineering Degree upon the completion of two or more years of highly specialized and very practical instruction.

During the past decade, American industry has as a whole, made tremendous progress in all technological fields. The success of our industries and the high level of production which they have attained has not been so much the result of individual effort as it has been the result of team-work within the engineering departments of these industries. A constantly increasing amount of attention has been paid by these departments to the organization and functioning of what is now known as the engineering-team. This team usually consists of the professional engineer, several engineering technicians and a group of skilled craftsmen. The engineering technician finds that his job on the engineering team requires some of the knowledge of the engineer and some of the skill and know-how of the craftsman. His is the job that requires the combination of a high degree of specialized technical knowledge with a background of basic theory and a broad understanding of fundamental operational procedures. In addition to this general requirement, the engineering technician is usually specialized in one aspect of engineering.

The type of student who enters the technical institute has changed over the last ten years. In the past, student groups averaged 23 to 25 years of age. They seemed better oriented to college work and were capable of rapid learning (many veterans being included in these groups.) Today, student groups average in the age bracket of 17 to 21 years. They need considerable guidance in becoming introduced to the serious nature of collegiate work and are not well prepared for technical institute education by their twelfth year of schooling. A solution to this problem might be the third-track idea that has begun in the Richmond City Schools.

Full credit for the work that follows in this report, is given to The Richmond Plan Group as follows:

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INTRODUCTION

The route which the Richmond Study Group has travelled since its first meeting in the Fall of 1959 resembles the path of one seeking to find his way through a maze. Ideas, programs, and structures have been groped for, defined, eagerly seized upon, and followed to their logical conclusions to end in a blind alley, - time and time again. The analogy of the maze breaks down at one point however. When one enters a maze he can be certain that the blind alleys will be easily distinguished from the objectives sought. He will know when he has lost his way and he will know when he has arrived at the end of his search. This however, has not been true in the development of this program.

In the early stages of the deliberations of this group, there was hope that some combination of purpose, structure, program, and services, would emerge from the array of alternatives before us and declare itself unmistakably to be the combination which could fulfill the objectives inherent in the charge given us. This too, has not been the case. Despite conscious and disciplined efforts to achieve objectivity, to observe carefully, to understand varied points of view fully, and to aid impartially from the mass of evidence available, the proposed plan of the third-track cannot claim to offer an indisputable answer to all the questions which confronted the original study group. Because the questions themselves are qualitative rather than quantitave, the answers often represent judgments, rather than certainties. The unanimous judgment of this group is that the plan proposed in this report, though debatable, provides a foundation for realizing the basic objective of providing improved educational service to the multitude of "average learners" who are now floundering in current college prep programs. It remains the task of the executive committee of The Richmond Plan as well as the Technical Institute, to evaluate and express thoughtfully and carefully, their own judgment of the success of the pre-technology program in terms of the entering students and later successful graduates.

In approaching its task, the Study Group was aware that its most formidable obstacle was the danger of pre-conceived ideas of basic assumptions. The resulting attempts to achieve objectivity lead to the questions put to the members of the group by the chairman in the first summer workshop in 1961: ..."If no curriculum such as a pre-college preparatory program existed, what kind of a program should be created to serve the purpose of the technical institute? Should such a curriculum be administered by one department or be inter-departmental in nature? Should the organization of the curriculum be designed for the benefit of the local community institution or for the benefit of all technical institutes?

The major activities during the first workshop were:

A. Fact Gathering: Each member of the Study Group, before attending the workshop was required to read the "Carnegie Report - THE TECHNICAL INSTITUTE IN AMERICA," by G. Ross Henninger. Leaders in technical institute education in northern California were then invited to meet with the group to discuss technical education today. This included an historical review, definitions and a long discussion period. The group then spent a great deal of time in the study of technical education in California. This included types of technical education programs such as technical institute curricula of the California public junior colleges, State colleges and universities, Cogswell Polytechnical College, City College of San Francisco, Sacramento City College, Stockton College, Contra Costa College and Diablo Valley College, etc. Attention was next turned to current problems in technical education which included among others - student preparation in mathematics, science, and industrial arts; diversity of junior and senior high school offerings, diversity of programs offered at college level, variations, definitions and interpretations of technical education, status in the community and employment. This was followed by visits to the local industries employing technical institute graduates. Discussion were then held with employers; The California State Department of Employment; Secondary School Administrators, mathematics teachers, industrial arts teachers, university professors, the public junior college engineering teachers, the public junior college administrators, the public junior college industrial arts teachers, and professional organizations.

Finally, technical institute graduates were interviewed at some length. These technical institute graduates included very recent graduates as well as those who have been out in industry for a number of years. After this session, the workshop participants were asked to submit a hypothetical plan for high school preparation for college level technical institute education.

The areas to be developed were:

- a) mathematics
- b) science
- c) industrial arts
- d) communications
- e) civics and history
- f) physical education
- g) other subject areas

This was the first of many, many hypothetical programs which were developed during the next year, until the final program was assembled as shown in this report. Again, to insure objectivity and to be certain that not only Cogswell's ideas on technical institute education were used, faculty members from City College of San Francisco as well as Sacramento City College were brought in to lead discussions on the "place of the engineering technician" - in definitions such as "the technical laboratory" and what it means, in terms of in-service training for faculty members concerned with pre-technology, etc.

B. Analysis: The discussions which followed the presentations made by leaders in education evolved around "where do we go for help?" At this point, we brought in consultants from industry such as Dr. Robert Mager, Director of Training at Varian and Associates. Dr. Mager's help in assisting the group to determine specific objectives of the pre-technology program was invaluable. At this point, under the direction of the faculty at Cogswell Polytechnical College, the Richmond City school teachers submitted the first technologist outline for consideration by the administration of the Richmond City Schools System. A formal presentation was given, both to the top administrators of that district and to the Richmond School Board.

The proposal which was finally submitted to the superintendent follows in this report on Page No. 6.

C. Testing of Ideas: The first six weeks' workshop was completed during the summer of 1961. Throughout the next school year the Richmond Group met every Saturday morning in order to test the ideas and curriculum as developed at the conclusion of the first workshop. It is still the understanding of faculties at both Harry Ells High School and at the De Anza High School involved in the technological program, that the basic principle and original concept of the program as approved by the Rosenberg Foundation, Cogswell College, and the Richmond School Administration, is as follows:

The program is a pre-technical training program, not a terminal one. This necessarily involves several departments of the school functioning as a team: - English, science, mathematics, drafting, and the shop areas; that the basic course content in each subject can be compared to the content usually offered in these courses, except certain other features will be stressed, and that only the approach and teaching methods may differ, and that the teachers teaching in these areas need to be fully qualified in the subjects so that the whole curriculum development be an inter-departmental undertaking. This program is neither complete "shop" nor "classroom" in scope, and the crossing of the departmental lines will contribute to more effective learning for the students involved. In the appendix of this report are found some of the communications that took place during the year and the development of the final concepts of this program.

All materials were submitted to the District's Curriculum Committee under the direction of the Superintendent for Instruction, and the following proposal submitted to the Superintendent and his staff.

* * * *

PROPOSAL TO SUPERINTENDENT FOR A TWO YEAR PRE-COLLEGE TECHNOLOGIST PROGRAM.

SECTION I.

Teachers give much serious thought to the many problems of education that beset them in their striving to fulfill their important responsibilities. One of the most persistent and frustrating problems and one that remains largely unsolved is the problem of the bright youngster who fails to perform up to his capacity and who thereby fails to realize his vocational possibilities.

There is a considerable group of such youngsters who have had ambitions for careers in science or engineering but who, by the end of their tenth or eleventh year in school, find themselves not maintaining the pace in a program devised for university-preparatory students. Without a program of orientation and readjustment to substitute goals which are tangible and realistic, they often give up their science and mathematics altogether and take the course of least resistance for the rest of their school careers. Some of them get a new start on the junior college level, but spend a good deal of time making up what they should have done in high school. Most of them, however, never find themselves in a technological society which is demanding ever greater background and training to fill the many highly skilled positions available.

Another such group consists of boys who because of environmental influences have never seriously considered educational goals beyond high school. Some of these boys have a high degree of mechanical and mathematical aptitude. Proper orientation and an on-going program would interest some of them to the extent of causing them to work up to their capacities.

A third group is made up of a small handful of students who have somehow become aware of the opportunities in mechanical, structural, or electronic design and who are vigorously pursuing their goals, often laboring under a handicap in competing with the ablest of college prep students in their science and mathematics classes. Such boys would profit immensely from courses geared to their vocational goals and which emphasize practical applications more than theory.

We, a small group of teachers and administrators, have concluded, after careful investigation and discussion that there may be a constructive solution for a good number of such students. We feel that a program can be devised which will motivate these students to work more nearly to the limits of their capacities and which will provide for them vocational opportunities which they do not have under the present curriculum offered them.

There is at present a demand in industry for engineering specialists who are equipped to fill the gap between the skilled craftsman and the graduate engineer. The demands of the future for this type of specialist will be even greater. We quote from an article in Changing Times (November 1960) entitled "The Best Jobs now and the Years Ahead:"

"A major trend (1960-1970) is the rapidly increasing demand for semi-professional technicians of all kinds. The growing complexity of industrial processes requires teams of workers with technological knowledge and manual skills to help scientists and engineers. Demand will grow rapidly for aeronautical, electronic, automotive and diesel, civil and construction, chemical and safety technicians; for tool designers and draftsmen; for mathematics and engineering aides; and for x-ray, lab and other medical technicians."

The program which we suggest will serve to train students for these areas mentioned in the article. The two-fold need for the development of this curriculum - - need of students as well as the Technical Institute - - is very apparent.

Intense interest in our proposed program is already manifest. It will be a subject of discussion at the conference on mathematics at Asilomar on December 8 and 9. According to reliable reports, representatives of the Rosenberg Foundation are seriously considering a sizeable grant of money to the Richmond Schools should they be convinced that an experimental program will be conducted vigorously and enthusiastically. Our problem is to decide whether it is desireable and feasible to initiate such a pioneering program in the Richmond Secondary School District.

It is appropriate at this place in the report to indicate something of the nature of such a program in a high school. Interested teachers at Ells teaching the subjects of mathematics, English, metal shop, and physics, have offered samples of the kinds of work in their fields which they feel would be appropriate to such a curriculum. The report submitted by Mr. Dunning happens to be fairly elaborate while the one from Mr. Kevell is quite brief though comprehensive. These are not complete detailed reports but we have decided to submit them in this paper as they were submitted to us. It should be noted on reading these samples that there is an emphasis on practical applications and a certain integration of subject fields apparent in the shop offerings which differ markedly from conventional shop offerings on the high school level. Here the emphasis is on the application of science and mathematics. In addition, the suggestions of Mr. Kevell for shop projects applying scientific and mathematical principles are quite interesting.

Preceding the sample course offerings is a course of study by subject title and grade level as conceived by the teachers and administrators involved in our preliminary studies. Following this, Mr. Johnson will discuss the problems of administering the experiment in its initial phases. At the close of this paper we shall summarize our study to date; discuss the opportunities of students who may complete such a curriculum; and respectfully offer our recommendations to Dr. Miner and others concerned with the evaluation of this report.

We have asked Mr. Marvin J. Feldman, Vice President of Cogswell Polytechnical College, to present an oral report to you so that the district will understand the responsibility of the Junior College in helping us to develop the paper curriculum.

SECTION II.

The problem of selecting the students who will participate in the pre-college technician program is difficult, if not complex. There are many factors which have to be considered. Some of the factors are as follows:

1. Is there evidence of self-motivation that would carry the student through such a program?

2. Is his grade point average such that it would be indicative of probable success?

3. Does he have sufficiently high enough scores on the D.A.T. - specifically Mechanical Reasoning, Numerical and Verbal Reasoning, to indicate that he has an aptitude for such a program (50th percentile)?

4. Are his parents willing to accept this program in lieu of another course of study?

5. Does he have the necessary interests for such a program?

One of the pitfalls to guard against in the initial program will be to avoid selecting youngsters who are not strongly motivated. Only those boys who have exhibited a strong desire to succeed should be selected for the initial program. It is recognized that a certain degree of motivation will be in the program itself, but on the other hand, there will be enough problems curricula-wise, staffing, vertical and horizontal articulation with other classes, etc., to make it difficult to place students who need supportive motivation in the program at this time.

Evidence of self motivation can be gathered from his teachers, from an examination of his grades from the 7th grade to the end of the first semester of the 10th grade. In each student's cumulative record file there is usually a certain amount of anecdotal material that should be helpful. Perhaps, it might be necessary and worthwhile to develop some sort of rating or profile sheet that would act as a common denominator for teacher judgment in evaluating self motivation.

The second factor is empirical in nature, i.e.: the grade point average. The question is what would be an acceptable average? Should all subjects taken be counted in determining the average? Since all students will have somewhat the same course, all subjects should be considered.

The third factor, and perhaps the most important, is the matter of choosing the best objective device for measuring student's aptitude and ability to succeed in such a program. The avoidance of single-score-measuring devices should be self-evident. There is not multifactor aptitude test yet devised that differentiates between aptitudes with any high degree of validity; the Differential Aptitude Battery is one of the best and can be easily administered and scored. It also provides us with many studies of predictive value in relation to higher institutions as well as occupations. The question is - what should be the cutting score - certainly nothing less than the 50th percentile on the VR*NA score. The mechanical reasoning and space relations test would also provide us with an index of the kind of aptitudes needed for a career as a technologist. Again, in the initial program our sights should be higher and therefore it is suggested that the 60th percentile be used as the cutting score. It is, however, quite probable that a boy might score between the 50th and 60th percentile and still be given strong consideration providing his mechanical and space relations scores are high and his grade point average a "C", - "D".

The fourth factor - are the parentswilling to accept this program in lieu of the regular college preparatory or industrial arts course of study? This will call for a very intensive educational program. The parents must be assured of the fact that these students can enter a college if they so desire, and that they will be well prepared to enter a variety of courses on the college level. It is important, however, that they realize that we are not thinking in terms of the University of California, Stanford, or California Institute of Technology. We are thinking in terms of Cogswell Polytechnical College, of many Junior Colleges, of California Polytechnical College of San Luis Obispo, and perhaps the Engineering Schools at some of the State Colleges. The parents should be very carefully apprised of their child's ability and his chances of success both at the former as well as the latter institutions.

The last, and perhaps the most difficult factor of all is the matter of interest for the program on the part of the student. Though much research has been and is still being made, on how to measure interest, and much data is available, there are many questions still unanswered. Though a counselor might have on hand an interest questionnaire or inventory, it is still highly debatable as to the validity of such instruments. Dr. Froelich in his book "GUIDANCE TESTING" points out that "the making of judgments about an individual's interests, whether done on a basis of test data or on information gathered by non-test methods, is probably one of the most difficult aspects of guidance work. For this reason the ...counselor...should interpret interest data with the greatest possible care and thoughtfulness."(1)

In the light of all the evidence as to the lack of adequate tests to determine a valid interest level, it is felt that at least three measures be used. First, a question and answer interview, structured so that the approximately same questions be put to each boy being considered for the course. The purpose would be to find out what he likes to do. The answers, however, will not always be complete, but it will give the counselor an idea of what the student expresses as his interests. Second, an attempt should be made to list and analyze his activities, hobbies, and forms of recreation. Last, some for of an interest inventory should be administered. It is suggested that the Kuder be used, both the Kuder Preference Record-Vocational, and the Kuder Preference Record-Occupational. The latter is a follow-up on the former. It will provide some information about vocational interests as compared with men in specific occupations with comparable interests.

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(1) C. Froelich and K. Hoyt "Guidance Testing" Science Research Associates, Inc., Chicago, Chapter 9, p. 174

***(Preliminary course outlines were submitted to the Superintendent).

Finally, it should be apparent that the decision to place a student in such a program should not rest with a single individual, but should be shared equally by several. The counselor would collect the data on each student to be considered and present it to a committee which will in turn make a decision based on all the available evidence.

SECTION IV.

In conclusion, we realize that this report does not give adequate coverage to all the thought and research that has gone into our investigations. We have not mentioned the invaluable assistance of Cogswell Polytechnical College and their able representative, Mr. Feldman. We have perhaps neglected to be specific as we might have been about certain phases of the program which might be of interest to Dr. Miner and his staff. We do hope that some one of us, and perhaps Mr. Feldman too, will be allowed to be present when Dr. Miner and his Advisory Council are considering this matter so that we may help to clarify any questions which come up that are not adequately covered in this paper.

We who have participated in this study started with an initial enthusiasm that has not lessened but increased, as we have realized more and more the manifold possibilities of such a program. It may provide both the shorter-range goal of a two-year terminal course beyond high school, and the opportunity to continue beyond that in a four-year engineering course in a choice of several colleges. It is excellent preparation for teacher training institutions other than the major universities. It is excellent preparation for apprentice training. In short, it may provide both incentive and opportunity for those who can make a better adjustment in this type of program than in the traditional college-preparatory course.

We are aware that such a program must be experimental in nature and can be thoroughly evaluated only as it progresses. We realize the hours of labor necessary to prepare for the first experimental group to begin its two-year program. We realize the labor and expense and at least some of the problems involved in carrying out the program over a two or three year period. We have reason to believe that much of the extra expense will be borne by grants from outside agencies.

We who have initiated this study will gladly bear our share of the work necessary to bring this program to fruitage. We hope Dr. Miner and his staff will see fit to give our thoughts and plans their most careful consideration.

Respectfully submitted,

THE COMMITTEE

THE PRE-TECHNICIAN PREPARATORY PROGRAM
(THE RICHMOND PLAN - 1962)

Introduction to the Program

WHAT IS IT?

A program to prepare capable average college prep students for a two-year technical institute program in public or private junior colleges. This is not a terminal program, but an institute-prep program.

WHAT IS THE NEED FOR THIS PROGRAM?

Automation is requiring more and more technicians. The present technician is developed from youngsters who have varying high school backgrounds. This Program will offer a well-rounded education to high school students interested in the technical field. It will give students the opportunity to explore college-prep subjects from the practical application view rather than from the abstract. With this grasp of fundamentals, students will be able to go on to technical institutes, colleges or vocational schools with backgrounds that should insure success.

HOW ARE HIGH SCHOOLS MEETING THIS NEED?

Currently, the only preparation is in the traditional college-prep track, which has emphasis on the abstract. There is little or no opportunity for the exploration of drafting and shop experiences, two necessary fundamentals for technical training. Further, the sciences are not related to the practical shop experiences that would make them real. In brief, the comprehensive high school is not meeting the needs of an automated society.

IS THIS A 'WATERED DOWN' COLLEGE PREP TRACK?

This is a specialized track, featuring practical learnings, to educate technical-minded high school students who can move into technical institutes with a solid background. The high school student, with technical learnings, can be given a practical college prep education which will serve him well in these institutes. The engineering technician is a member of the largest single group of specialized graduates from schools of higher learning. This fact cannot be ignored.

We believe that with enthusiastic teachers and a properly motivated group, evaluation will show that these students will compare most favorably with their counterparts in the traditional college prep track. Overworked 'motivation' usually indicates stimulation through fear of reprisal. If you "don't do the assignment your grade will be lowered." In this program, each youngster has to be made aware of his strength and limitations. And, likewise, so must the teacher be aware of these factors. The student will start where he is and progress according to his abilities.

Should a student find the Program not meeting his needs, he may be moved into another track.

WHY IS THIS PROGRAM "SPECIAL?"

This is the first Program to consider the "average" student in relation to higher education. This is the one who is often neglected while the gifted and retarded are provided for in special programs.

Ultimately there will be three paths in the Program: one for the engineering technician; the vocational technician; and the craftsman.

The Program is geared to wide area needs of technicians in industry. We must accept the fact that our economy requires a continual flow of technicians. The high schools are failing when they refuse to recognize this precept. The high school is also failing when it categorizes students in relation to 'norms' and ignores the individual's potential.

WHAT ARE SUCCESS POSSIBILITIES OF THE PROGRAM?

In our district we normally average about 33% of our high school students in the college prep track. We have data to indicate 5 to 10% of all high school students graduate from college, which at best would mean one-third of those who were high school college prep. What happened to those who failed? How are they prepared to earn a livelihood?

With proper instruction and counseling, at the appropriate grade level, we could - and should - find that the majority of those who are not succeeding could find a useful and interesting place in industry. This is not a 'miracle' Program; to the contrary, it merely accepts an automation truism and sets about to best meet the needs of industry through institutes.

HOW WERE THESE CONCLUSIONS DERIVED?

At a Summer Workshop, 1961, eleven educators worked on the Program. Prior to developing concepts, beliefs and curricular offerings, they were involved in discussions with representatives from technical institutes, persons in industry, and research and technical institute graduates. They found that industry has need for the technical institute graduate as he is now trained; that his training is modified at the technical institute to the needs of industry. The technical institutes said, "Give us students with this high school background and we can do a better job of teaching."

With this background and these understandings, we proposed this Program which was completed in August of 1962.

BACKGROUND TO THE PROGRAM.

Culminating a pre-engineering technician Program workshop during the summer of 1961, the following materials and recommendations were developed. Workshop participants included personnel from De Anza and Harry Ells High Schools in Richmond, and staff members of Cogswell Polytechnical College of San Francisco. The general plan during 1961-1962 was to identify the student, counsel with him and with his parents, and program him to his 11th grade course of study. In addition, selected, interested teachers, were offered the opportunity to develop subject matter, determine texts, select teaching materials and aids and attend in-service training programs sponsored by agencies without the school district.

Currently, industry has a tremendous need for trained technicians. Sources of supply are graduates of technical institutes, college engineering students and high school apprentices.

The best source of technicians is from the technical institute. However, these institutes derive their trainees from high school students who are either traditional college prep or those with no inclination to attend college. This results in the institutes offering a make-up program that could be eliminated if students had a proper high school background.

A pre-engineering technican track in the high school would afford a rich curriculum to students who could go on to technical institutes and within two years receive the training necessary to prepare them for industry.

Technical institutes place all their qualified graduates and could fill many more positions if they had the qualified student personnel. This shortage of qualified personnel is becoming ever more acute. It is imperative high schools recognize this fact and take the initiative in preparing capable students for this advanced training and eventual employment.

Through team-teaching, correlating academic subjects to the technological laboratory and through constant theory/application techniques, the student can empirically develop an appreciation of subject matter that will aid him in establishing realistic goals.

Finally - the Program is offered as a potential aid to the mental or psychological high school drop-out - - that student who finds himself unable or unwilling to compete with fast learners in the college prep program and drifts through his high school years barely passing. He has no goals and no motivation.

To better understand the Program, there is a need to understand definitions, purposes, and the role of personnel involved.

DEFINITIONS AND GOALS.

Technician: The post-high school formally trained member of an engineering team who correlates the theoretical sciences to the practical arts in the design and development of the ultimate product.

The engineering team is made up of: the engineering scientist, engineering technician, and the craftsman.

Technical Institute: An institute of higher learning beyond high school, usually found as a division of a public or private junior college, whose purpose is to offer a formal training in the field of engineering technology.

Pre-Technician Program Student: The capable, average, college prep student who exhibits through desire, teacher observation and standardized tests, the potential to succeed in an engineering technician program. Also included in this Program would be the capable student from any track who could meet the described criteria.

Counseling: The student to be counseled into this program will be selected by evaluating:

1. teacher observation
2. student interest and motivation
3. academic records
4. accumulative test data
5. parental interest

Teachers within the Program will offer guidance and assist as group counselors. Continual accumulation of data will be an integral phase of the Program.

The counselor will accumulate all data, arrange for individual and group counseling conferences and be read to make recommendations on all phases of .he Program.

The Teachers: Are responsible for developing and implementing an interdepartmental curricular pattern that will meet the objectives of the Program. Individual recommendations will be reviewed by the Program teachers.

Administration: The district Program will be under the direction of the Director of Instruction. The Administration of the local school Program will be under the supervision of the principal, or his delegated authority.

The Student: Naturally, the most important factor in the Program is the student. The candidate for the Program will be the student who is not particularly successful as a member of the traditional college prep track. He will have been fairly successful in some subjects, poor in others; his saving factor will be "potential."

The prime purpose of the Program is to prove to the student that he can succeed, not merely pass tests and earn grades, but understand what he is doing and why he is doing it. His success will be measured by what he has learned and can demonstrate, not how he can parrot a series of rote learnings.

By getting away from subject matter compartmentalization, the student will be shown the rational integration of the sciences and the arts so that a finished product, well done, is resultant.

THIS IS THE KEY TO THE PROGRAM.

ADMINISTRATION OF THE PROGRAM

The responsibilities of administration fall into the following categories:

1. Determine the need for the program
2. Develop sympathetic administration
3. Determine the availability of teachers
4. Determine availability of space and equipment
5. Responsibilities of the local administrator
6. Pre-plan the program
7. Responsibility of selection of candidates

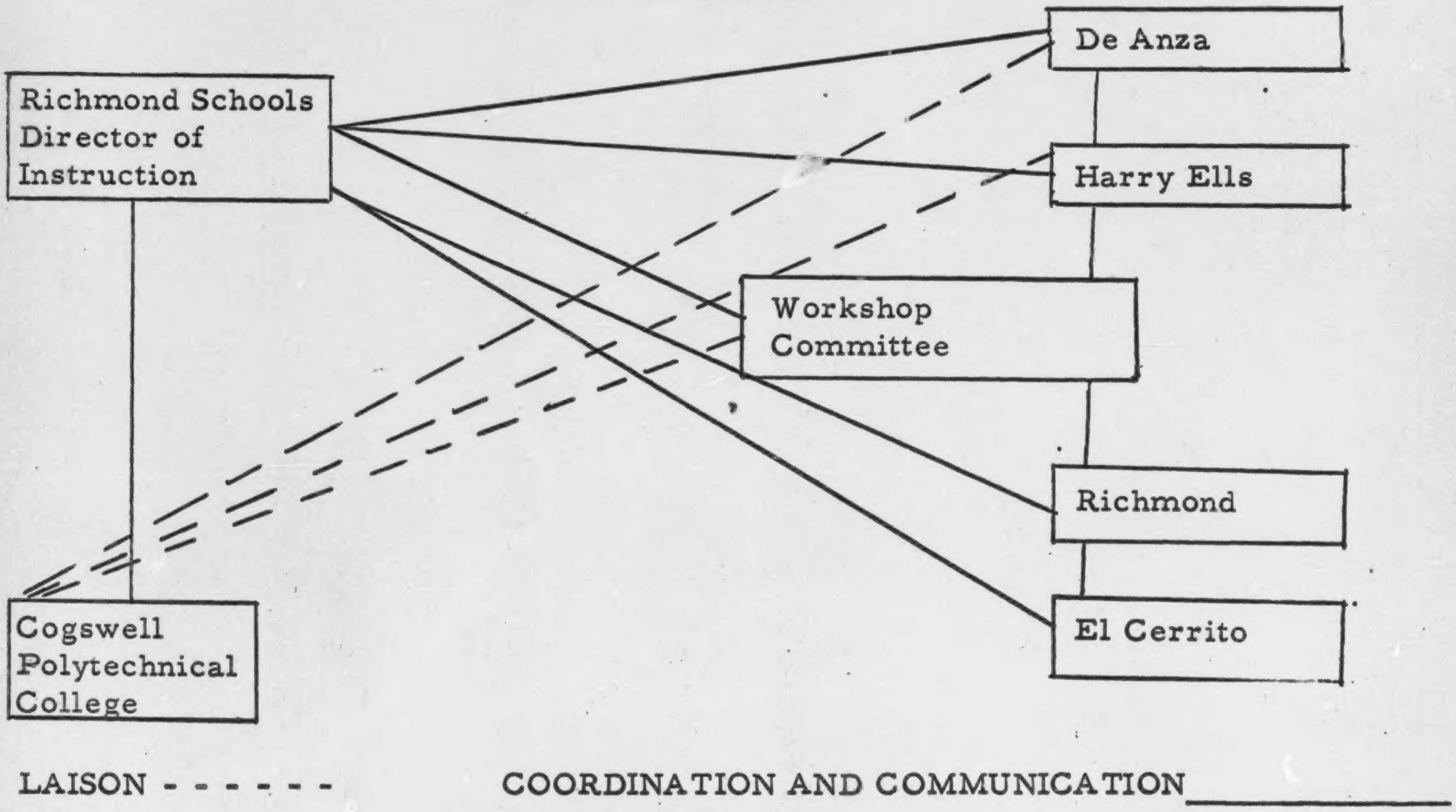
1. DETERMINE THE NEED FOR THE PROGRAM

We know there is a need for technicians in our society today and the need becomes greater each year. We also know that in our high schools today, a good number of young people interested in engineering, now enrolled in traditional college preparatory courses will not make grades high enough for college entrance. In a sense, these capable students are lost in the present school set-up. Because the college preparatory track is so competitive, these students flounder - feel a sense of failure and often fail to realize their full potentials. The pre-technology program for high school students with engineering interests is a new track which meets the requirements of technical institutes. Students who "find" themselves after high school graduation, will not have their way blocked, if they wish to complete work for a traditional four-year engineering degree. On the other hand, students completing two years of successful work at the technical institute may be employed in one of a variety of technical positions. Certainly, we can assume there is need for a third-track in the high school curriculum if the school is located in a large metropolitan area where numbers of students would benefit.

2. DEVELOP A SYMPATHETIC ADMINISTRATION

The question must be asked, "Is there a sympathetic administration to offer assistance and cooperation in the planning stages and to aid and counsel programming of the courses involved?" To be successful, the program in each school must have an enthusiastic administrator who will smooth the way in this departure from traditional academic tracks. The principal or his delegate for the program "advises" rather than "supervises." He is a working member of the team and available to explain administrative policies as they affect the program. The superintendent's delegate will also serve in an advisory capacity and be the laison between school and central office administration.

The following flow chart describes the method in which The Richmond Plan was administered under the direction of Cogswell Polytechnical College:


Richmond Schools Director of Instruction
De Anza
Harry Ells
Workshop Committee
Richmond
El Cerrito
Cogswell Polytechnical College
LAISON - - - - - -
COORDINATION AND COMMUNICATION ______

3. DETERMINE THE AVAILABILITY OF TEACHERS.

Are there interested teachers available? Teachers cannot be merely 'assigned' to this program. They can be recruited only after general faculty discussions and exploratory sessions in each of several departments wherein the basic program is described and its special demands outlined. The teachers must understand that the program will entail a belief that the student's success is the responsibility of the teacher; that the plan involves closely integrated team-teaching; that he will be involved in numerous meetings for evaluation for discussions and students' progress; and that the content of the course he teaches be adaptable to the ever changing needs of technology. It can be assumed that all teachers would not be able to adjust to this type of program. Once the teacher has elected to teach in the "track" - it can be assumed that he is willing to initiate, clarify, and refine the curriculum, and to expedite all teaching methods to better obtain the goals in this third-track.

4. DETERMINE AVAILABILITY OF SPACE AND EQUIPMENT

Once the program has been implemented, there obviously is no increase in cost to the school district than it currently spends in a comprehensive high school. An important consideration, however, is the availability of space, facilities, and supplies for the program. Ideally, the drafting room should be located next to shop areas.

5. RESPONSIBILITY OF THE LOCAL ADMINISTRATOR.

The administrator must know the goals of the program. Briefly, the primary objective of the pre-technology program is to give a solid integrated background in English, science, mathematics and drafting-shop work, which will prepare high school students after graduation for the intensive specialized training in a technical institute. It can be assumed that a high school graduate who has succeeded in the "track" will be better prepared for further technical training than a "general track" student. The curriculum is geared to meet the requirements of technical colleges in general, and the specific local technical institutes particularly. The administrator must know that the teachers in all four departmental areas will work together to coordinate as far as possible, the learnings of subject matter.

In the sections which follow, the method whereby this integration is attained, is outlined. The local administrator should encourage, provide space, offer guidance and help to the teachers involved, by continuously evaluating and defining the various phases of the curricular pattern. He should continuously study the operations to stimulate the concept of close integration in the various instructional areas. He, as well as the teacher, must be personally aware of the expectations of local institutes, by making visits and observations of these colleges in action. Each teacher should share the counseling and guidance of each student in the program. For example: each teacher and counselor should be aware of the availability of E.C.P.D. accredited programs at the technical institutes. Each teacher should have material available that will enable the fast as well as the slower student to maintain a definite learning pace.

6. PRE-PLAN THE PROGRAM

Prior to September, 1962, when The Richmond Plan went into operation, there had been completed over a year and a half of preparatory work in the first phase of the program. The first phase will be subject to continual evaluation in its initial year and modified and refined in the summer institute which is schedule in 1963. Throughout the planning of the first phase (11th grade), thought is being given to the second phase (12th grade curriculum). While the first phase is in progress, definite curriculum materials will be made for the second phase. All in all, hundreds of hours will have been spent in working out the details for the curriculum. Each unit of work, whether math, physics, English, science, or lab, will have definite measurable goals, and objectives stated clearly in understandable terms. Each day's work is pre-planned so that it makes a definite step toward the stated goal. Students will be aware not only of the goals to be reached in the units of work, but also of their own individual goals for each day. Textbooks have been selected which encourage progression on the individual basis and lend themselves to self-testing.

The stress on "measurable goals" is a part of what makes this program unique. As important as the content of the course is the testing program which measures, on an individual basis, the success of each student, on his ability to grasp the concepts set up as goals. Testing becomes a part of learning and a strong aid to motivation when used in this way. Student and teacher work together as a team in this approach. Because of the pre-screening of students, the thought of failure is non-existent. If there is lack of understanding and failure in any one test, teacher and student back-up and try to discover 'why.' Each unit is a hurdle and each taken in turn, there can be no "lost" student in the Program. In the pre-planning stage, every effort has been made to coordinate the four areas of learning so that they will augment and stimulate learning in each of the areas. English-grammar and skill in written expression - learned by a student is used in his lab reports because the subject matter of a theme will be --- "the lab report," if it is at all practical. Because of this aspect of the program, the teachers in the four areas have worked together as a team, coordinating their lesson plans and defining their individual goals and objectives as a part of the total common goal of a pre-technical student to meet the requirement of a technical institute. Students are encouraged to understand WHY they are learning what they are learning in all areas, and teachers themselves will know WHY students are learning what they are learning in subjects other than their own!

7. RESPONSIBILITY OF SELECTION OF CANDIDATES

A pilot class in pre-technology in a single high school should probably have about 30 students. The first step would be to screen all possible candidates by reviewing profiles, test data, and student achievement. It would be well to make up a potential list of 60 or more for this group with a panel of teachers and administrators serving as the reviewing board for the final list.

Step two is to contact and invite the 60 or more young people and their parents to a general meeting where the Program is explained in a half hour presentation. Parents are then invited to question the individual educator and pose any problems. Following the question and answer period, applications are given to the parents with the suggestion that they discuss the program with their children and submit the application if the child wishes to enroll. A pitfall to avoid is "over-glamourization" of the Program. "Selling" should be on a basis of opportunities for young people in technical fields and the type of technological training available for students following graduation from high school.

Assuming more than 30 affirmative responses are received, the faculty group would meet to determine who should be in the program. It may be that some candidates are still potentially successful in college-prep, and they should be counseled as to their futures in or out of the program. Following the final screening, the last step would be to have a general meeting of the successful candidates. Be honest with them! They are going to work hard! But all five teachers are going to work as a team. These students are not individuals competing against each other, but individuals striving for success through mutual efforts.

A FINAL WORD ON ADMINISTRATIVE RESPONSIBILITIES!

Build up within this group a feeling of pride and status within the school! A pre-tech student will receive guidance in most personal areas that will assist him not only in his school career but also later when he seeks employment and becomes a member of his profession.

There will be discussions on proper attire and grooming; personnel managers will be brought in from industry to discuss the methods of interviewing; there will be information on etiquette. The student group will plan dances and dinners and parent get-togethers. The pre-tech student is a special student in a desirable sense ...he has been selected on the basis of past performance or a keen special interest. He knows where he is going, and teachers, counselors and fellow students are dedicated to help him achieve his goal.

THE COUNSELING ROLE IN THE RICHMOND PLAN

The counseling role for the Richmond pre-technician program involves the following areas:

1. Selection Procedures
2. Motivation of Candidate
3. Publicity
4. Individual Progress Interviews
5. Programming
6. Program Status
7. Evaluation

1. SELECTION PROCEDURES

The counselor initiates the first screening of candidates who may be successful in the high school pre-technician preparatory program. The criteria for selection this first year consisted mainly of the results of the Differential Aptitude Test Battery. D.A.T. tests used in meeting selection criteria are:

a. Verbal Reasoning (VR) is a measure of the ability to understand ideas or concepts framed in words.

b. Numerical Ability (NA) is a measure of the student's ability to reason with numbers, to manipulate numerical relationships and to deal intelligently with quantitative materials. It teams with the Verbal Reasoning test as a measure of general learning ability.

c. Abstract Reasoning (AR) supplements the general intelligence aspects of the Verbal and Numerical tests. It involves the ability to perceive relationships in abstract figure patterns - generalization of principles from non-designs. Under ordinary conditions, the Abstract score will be relevant when the curriculum, profession, or vocational requires perception of relationships

POOR ORIGINAL COPY -
AVAILABLE AT TIME

among things rather than among words or numbers. In this sense, it may be as properly grouped with the Space and Mechanical tests as with the Verbal and Numerical. Since the ability to reason with words is not the same as the ability to reason with abstract figures, the Abstract Reasoning cannot substitute for the Verbal Reasoning test.

d. Space Relations (SR) is a measure of ability to deal with concrete materials through visualization. There are many vocations in which one is required to imagine how an object would look if made from a given pattern, or how a specified object would appear if rotated in a given way. This ability to manipulate things mentally, to create a structure in one's mind from a plan, is what the test is designed to evaluate.

e. Mechanical Reasoning (MR) may be regarded as one aspect of intelligence, if intelligence is broadly defined. The person who stands high in this characteristic finds it easy to learn the principles of operation and repair of complex devices. The test is useful in those curricula and operations where an appreciation of the principles of common physical forces is required.

One looks for a result between the 50th to the 75th percentile on the above tests. Thes scores represent the average to more capable youngsters. In addition to the D.A.T. test battery reading and arithmetic achievement test scores are also included in selection criteria along with intelligence test scores. The average youngster is sought who performs near grade level in achievement. However, since the program of studies is technical in nature, those students scoring above grade level in arithmetic are given preference, all other things being equal.

Although specific courses are not necessarily a criteria for selection, it is to the advantage of the youngster if he has had some higher math - preferably a year of algebra. In this pilot project, however, we will be trying to find out the lower limits of the various criteria used in the selection process. As we get into the first year, there will be a continual evaluation process, and changes in the selection criteria will be made. Already some of the instructors feel that at least a year of algebra is absolutely necessary with a "C" mark or higher, and at least a year of geometry with nothing lower than a "D." At the present time, because we are using different approaches, techniques, and material, we cannot safely say with any validity what the exact ranges of our criteria should be. We are always more interested in each youngster as an individual than his closeness of fit to any given scale. Motivation and drive are important and are weighed heavily in the final decision for including a student in the program. The personal interview and the teacher appraisal are most important in making some kind of judgment on a boy's drive and motivation. In the final analysis, the counseling process of selection is based on both objective and subjective data as interpreted by the counselor and teachers.

2. MOTIVATION OF CANDIDATE

Once the candidate is selected, every attempt will be made by all adults connected with the program to provide the necessary stimuli so that the youngster will want to succeed. Each adult in the group feels that he has the personal responsibility to see that each youngster does succeed. Many of these youngsters have previously been enrolled in college preparatory programs and have not been able to maintain the pace with university-bound students. It is hoped that the more tangible goals of the pre-technical program will activate these students to work more nearly to the limits of their capacities, and the training they receive will lead to vocational opportunities in our technological society.

Once again, the decision to place a student in the program should not rest with a single individual, but should be shared equally by several. The counselor collects the data on each student and presents it to an advisory council made up of administrators and teachers involved in the program. The advisory council makes the final decision based on all available evidence submitted by the counselor.

3. PUBLICITY

The counselor has now screened the youngsters based on the test results of the D.A.T., achievement test scores, etc. He has also reviewed the academic record of this selected youngster. If it is seen that he is not earning recommending marks in the program he is presently pursuing, and does meet the suggested criteria test scores, he is added to the possible candidate list.

The school newspaper, the daily school bulletin, the local newspapers are the means used to inform students and parents in the community about the program. In January, the possible candidates who in this case are present tenth grade students, and their parents, are invited to an open meeting at the school. All other interested students and members of the community are also invited. Each participating teacher makes a five minute presentation of his subject area. The important aspect of this program is to show how these teachers work as a team. For example, the function and use and physical laws involving the inclined plane could be a class lesson. The tech-lab course would build the inclined plane. The physics class and the math class would develop the problems to be studied and their solutions. The English class would be involved with the write-up of all experiments and conclusions to be drawn from the exercises. In this manner the youngsters see the correlation to and the reasons why each subject is important to the other.

The student is not dealing in abstractions. Every study has a goal that the youngster can develop and see its implications to a practical situation. This concreteness, it is hoped, will stimulate the student to work to his potential level.

At the evening meeting, after the teacher presentations, small groups are set up so that individual and specific questions can be asked of the teachers. The counselor who has arranged for this evening program is present along with the administrator of the program to also answer questions. If these screened candidates and their parents would like further information, conferences can be arranged with the counselor or the administrator. A list is then made of all students who wish to be a part of the program. From this list an additional screening is made to get the pilot group down to 35 students. This number will provide for a large enough group to continue on for the second year of the program allowing for students who move during the year. A conference of the teachers the counselor, and the administrator will then discuss each interested candidate. Individual interviews are made. Finally, 35 students are selected.

4. INDIVIDUAL PROGRESS INTERVIEWS

Every attempt will be made to have every child be successful in the program. Each youngster has the necessary aptitudes and ability to be successful. Any student failure can mean only that the adult team has failed. The counselor will meet with each child at least once a month in an interview setting. This meeting could be student or counselor initiated. One would hope that school or personal problems could be worked out so that the boy can devote his energies toward a successful school year. Bi-monthly meetings of the staff team will also be held. The progress of each student will be discussed from the orientation of each subject. Any weaknesses that a child has demonstrated can be worked on by each teacher regardless of subject area. It is the philosophy of this adult team that each child progress as much as possible during the year. Any weakness in evidence should be strengthened by all concerned so that maximum overall development of the learner can be achieved. The counselor will make suggestions to the teacher team based on information obtained in personal interviews with the student. The teacher team likewise will submit information to the counselor that will assist him in working with the individual boy.

5. PROGRAMMING

This program will operate on a seven period day, including a lunch period as do other tracks in the school. The pre-technician course offerings in grade 11 are physics, English, tech-lab, and algebra 2. U.S. history and physical education are required courses by the state. In grade 12, the course offerings will be mechanical drawing advanced, math analysis (including trig and geometry), tech-lab, and chemistry. American government and physical education will complete the course offerings to satisfy graduation requirements. The students will have all of their classes together with the exception of physical education and U.S. history in grade 11 and physical education and American government in grade 12. To differentiate these courses from other courses with similar titles, each of these courses with the exception of the required courses for graduation, will be followed with the capital letter "T" designating technician.

These students, upon graduation, should be ready to meet the requirements of the technical institute. The Richmond Plan has worked closely with Cogswell Polytechnical College in San Francisco, which provided invaluable help in a curriculum development that would meet entrance requirements in a technical program or institute. These students should likewise be qualified to enter any junior college technical program. When a transcript is sent to such a technical college or junior college, it is the plan to also submit an outline of the course content covered in these "T" courses.

It is not the objective of this program to prepare a student to enter a four-year college. The program is intended to train pre-technicians and upon graduation from high school these students may enter a technical college. However, should a student change his goals and wish to enter a four-year college, he may do so by taking college entrance exams or taking the junior college route.

6. PROGRAM STATUS

Every student wants to feel that he is in a valuable program and that the course offerings are preparing him toward a goal. The students comprising this initial program will probably feel a close tie toward one another and achieve a unity toward the program itself.

The school presently recognizes students in every subject area who are doing an outstanding job. It is hoped that a student within this program could receive this honor and be recognized at an annual scholarship and awards banquet or assembly so that pre-technician students may more closely associate themselves in this recognition of one of their own peer group and also that the student body may become aware of this program.

It is further hoped that upon graduation from high school that scholarship opportunities could be made available to at least one lad in the program as a material help to the student and as an incentive for others to achieve excellence and as a public relations program for the community.

7. EVALUATION

Subjective evaluation of the program by the teachers, the parents, the counselor and administrator, represent one phase of the program that will be made during the year and at the close of the year.

Objective evaluation will be another phase. The D.A.T. test battery has already been given each student. This test will be again given at the end of the second year to see if any changes in the sub-tests have occurred. At the beginning of the first year, an achievement test battery known as the Cooperative Tests of the Educational Testing Service will be given by the counselor in English, involving reading comprehension, mechanics of expression and effectiveness of expression, elementary algebra through quadratics, general mathematics for high school classes, and in physics. These same tests will be administered at the close of the first year to determine growth in achieve ment. It should be stressed that in every instance individual growth will be evaluated, not group growth. It is realized that although these young men have similar aptitudes, their individual achievement levels at the onset of this program do vary greatly. It is to the purpose of this program to motivate each youngster and to take him as far as possible. The group will always be secondary to the individual.

The students will not be the only learners. The team staff will also learn from the students. If this program is to provide the services to the average, capable child, it is imperative to know what the student can learn and at what rate he can absorb these learnings. It is anticipated that revisions in the general course outlines will be constantly revised during the year to meet the current needs of the individual boy so that the confidence he has in his own ability will be ever strengthened.

TEACHING METHODS FOR THE RICHMOND PLAN.

Preparing Instructional Programs for the "average learner."

We should like to acknowledge the help of Dr. Robert Mager, Training Director of Varian and Associates, who assisted the Richmond Group in the methods of preparing the course outlines for The Richmond Plan.

Based on Dr. Mager's methods of industrial training, it is necessary to make two assumptions about the instructors concerned:

1. We assume that it is important to the instructor preparing the program that every qualified member of his target pupulation will achieve specific objectives.

2. We assume that it is important to the instructor that he will be able to demonstrate that his educational objectives have been achieved.

With these two assumptions in mind, it is now possible to prepare instructional materials that are very much different from the traditional methods used in the secondary schools. There are seven steps to be followed in the development of the curriculum. They are:

1. Define the student
2. Specify the instructional objectives
3. Prepare the criterion examination
4. Prepare a list of pre-requisites
5. Prepare the content outline
6. Prepare an initial course sequence
7. Select the major teaching strategy

STEP 1 - Define the Student

Since all of the students in the pre-technology program have a single goal in mind, a description of the target population orients the teacher's thinking with respect to the vocabulary and explanations that he can use and the background assumptions he can make. This step is fairly simple.

STEP 2 - Specify the Instructional Objectives.

It is primarily in this area that teachers need guidance and time. THIS STEP IS THE MOST IMPORTANT PART OF THE ENTIRE PROGRAM.

As Dr. Mager pointed out - to build a curriculum that works, it is necessary to spell in behavioral terms just what the learner will be doing when he is demonstrating that he has achieved the specified objectives. Similarly, before a program can be evaluated the objective must be spelled out in measureable terms. It is absolutely necessary to specify objectives clearly in order to "teach a course." In a lecture given to the members of the Study Group, Dr. Mager pointed out: "The importance of preparing a statement of objectives for each educational intent can not be over-emphasized, and the benefits of doing so, are many. With objectives, it is possible to evaluate the effectiveness of an instructional program. With objectives there is a sound basis for selecting and sequencing learning experiences.

With objectives, it is most likely the teacher will not fall into the trap of equating the difficulty of content with it s importance. With objectives, the student is provided a tool which allows HIM to organize his activities effectively, and prevents him from having to develop tricks designed to rub the teacher the right way. The teacher will operate in a fog of his own making until he knows just what he wants the students to be able to do as a result of his instruction. Every student in the third-track is urged to know exactly what he is required to study and learn, and why he is learning that particular subject in terms of what he is going to do in the near future. The student should never have to second-guess the instructor, his textbook, or the program. He should be told not only what he will be able to do, but also what he will not be able to do."

STEP 3 - Prepare the Criterion Examination.

To prevent the teachers from falling into the trap of writing a test which measures whatever it is they have happened to include in the way of content rather than one which measures how well they have achieved the specified educational objectives, the teachers in the third-track prepare the criterion test BEFORE they prepare the curriculum. For only when the members of our student population perform satisfactorily under the criterion examination, have we completed the teaching task. This means that our instructors must decide beforehand what they consider "passing." The teachers must re-orient their thinking so that they are not interested in evaluating the student on the basis of how well or how poorly his peers happen to perform.

STEP 4 - Prepare a List of Pre-requisites.

The instructors must know exactly what they are going to assume in respect to prior knowledge and experience of their target population. They need this list so they cannot blame previous schooling for the failure of their students to have attained particular objectives.

STEP 5 - Prepare the Content Outline.

Once objectives have been defined it is relatively simple to prepare a content outline as will follow in this report.

STEP 6 - Prepare an Initial Sequence.

On the assumption that what is meaningful to the instructor is not always meaningful to the student, it is necessary in programming the third-track that the material be sequenced as if the learner had some say on the matter. If traditionally in a course of physics, mechanics is taught first, and if in this program, utilizing the team-teaching approach, trigonometry might not be offered until later in the semester, it might be necessary to change the course sequence to meet the student's needs.

STEP 7 - Select the Major Teaching Strategy.

The primary goals of any program involving "average" learners are:

1. To provide information to the student in small increments.
2. To cause the average learner to make responses conducive to his developing the desired efficiencies.
3. To let him know how well he is doing every step of the way.
4. To have the student demonstrate that he has reached the desired objective with some change in behavior.

Progress charts are developed so that each student knows exactly his standing on any day throughout the school year. For many teachers working with the average learner necessitates a rather serious change in attitude, for in this program the teacher must accept the blame if a student does not understand (for whatever reasons). The teacher must avoid becoming defensive. Every time a student fails the teacher must say, "Obviously I didn't make myself clear, let me try again."

CLASS ANALYSIS PRE-TECH PROGRAM - Harry Ells High School

Introduction:

The following tables and test results have been extracted from the school records of the thirty-two students who will participate in the pilot study of what is now called THE RICHMOND PLAN.

Procedure:

All data collected was tabulated into frequency distributions. From these the medians, quartiles, and quartile deviations were computed.

Analysis of Results:

The first data collected were the I.Q.'s of the various students. Each student, with the exception of four out of the thirty-two (who had only I.Q. score) had two or more I.Q. Scores. These covered a period of time from the third to the ninth grade. The tests used were all group tests: Henmon-Nelson, and California Mental Maturity. No attempt was made to analyze the scores at any given grade level. Two separate frequency distributions were computed. First, a distribution of the highest recorded I.Q.'s of each student was made. The median I.Q. is 115.7 with a Quartile Deviation of 5. Taking all of the lowest I.Q.'s of the students the median is 106.2 with a Quartile Deviation of 6.5, averaging the two arithmetically, we get an I.Q. of 111.0.

The next group of data to be analyzed was the results of the Differential Aptitude Tests. These tests were given in the 9th grade to all the students with the exception of seven students who were new to the school district. As in the I.Q. tests, frequency distributions were made of each sub test of the battery and from this data the Median's Quartiles and Quartile Deviations were obtained.

The following table gives the results in terms of percentiles:

Differential Aptitude Test

Test	Median	Q1	Q3	Q	Percentile	
					Low	High
Verbal	61.3	45.3	80.75	17.7	25	95
Numerical	67.5	45.5	72.5	19.5	25	99
Abstract	76.5	58.5	88.5	15.0	20	95
Mechanical	81.7	52.0	95.0	21.0	25	99
Special	80.7	63.0	92.0	14.5	25	99
Spelling	51.8	36.4	67.5	15.5	10	95
Sentences	50.3	28.5	63.5	12.5	5	90
Combined VR & N	71.0	50.5	86.7	18.1	35	97

The Median I.Q. suggests that the students fall in the high average category, but with a marked deviation in various aptitudes as measured by the Differential Aptitude Tests.

Here there is a great spread from the 99th percentile to as low as the 25th percentile in some of the sub-tests. It is interesting to note that in the Abstract Sub-Test there is a piling up at the top part of the scale, suggesting a certain amount of homogenity in this area. The same is true of Mechanical Reasoning and to a certain extent in Space Relations. This is to be expected and a certain amount of homogenity at the upper end of the scale in these tests suggests that as far as aptitude is concerned, these boys are in the right program.

However, there is still a wide spread in the combined score of Verbal Reasoning and Numerical ability which is used as a criteria to predict success in an academic college preparatory program. An inspection of the frequency distribution of these combined scores indicates that the group contains eight boys at the 80th percentile or above. The number of students between the 60th and 79th percentile is also eight. The mid-range between the 40th and the

59th contains 7 and 2 students fall below the 40th percentile. The actual spread runs between the 35th and the 97th percentile. Inspection of the two medians of the verbal and numerical scores reveal both medians below the median of the median of the combined scores. This is the result of special weighing given to the scores when they are combined.*

The last data extracted from the students records were the marks made in all classes taken in the 9th and 10th grades. In computing the statistics, only semester marks were used. These were converted into a four-point scale, i.e. A = 4 pts, B = 3 pts., C = 2 pts., D = 1 pt. The Median for the group was 2.3, the Q-1 was 2.1, the Q-3 was 2.7, and the Q was .30.

CONCLUSIONS:

All things considered, the I.Q. and the D.A.T. scores of these boys appear to fall into a high average or what might be better termed capable average. In any case, the 2.3 grade average suggests that they are capable of doing better. But this is not the whole story and statistics cannot reveal what we know concerning the motivation, drive, or complex personality of each of the students. The statistics are therefore quite unsophisticated, and they are meant to be. They are simply to give a broad picture of the class and to form some basis upon which a selection could be made. The real story is in the students themselves and the subjective analysis on the part of the teachers and the counselors as to why they think these students should be in the program. The hours devoted to interviewing each student, his parents, and conferences with his teachers have been great in number. Time and space do not permit an evaluation of all the data collected in these discussions. However, it can be pointed out that with the exception of one student, all were doing rather mediocre work in their college preparatory subjects, yet all were interested in becoming some kind of technician or engineer. Even those who were getting fair grades felt that they had just about met their limit. With the exception of one boy, all teachers felt this program was suited to their needs.

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*For further discussion of this, see the test manual of the Differential Aptitude Test by Seashore.

CLASS ANALYSIS PRE-TECH PROGRAM - De Anza High School

BASIS FOR GLEANING THE INITIAL GROUP

Define Average Capable Learner:

I.Q. -------------------------------------- 95 plus

D.A.T. (VR/NA) ------------------------ 50th percentile or above

Grade Point ----------------------------- C minus to B (Average)
(Selected Subjects)
- English
- Arithmetic
- Algebra
- Science
- Industrial Arts
- Language

Grade Level ---------------------------- 10th

Sex -- Males

Academic Track ----------------------- College Prep or General Curriculum

INITIAL GROUP SELECTED

Number ---------------------------------- 96

College Prep -------------------------- 77

General Curriculum ------------------- 19

SUMMARY OF MENTAL CHARACTERISTICS OF THE INITIAL GROUP - 96 BOYS SHOWING SIGNIFICANT PATTERNS OF FREQUENCY DISTRIBUTION AND CORRELATIONS.

INTELLIGENCE QUOTIENT

Range	N
95 - 104	6
105 - 114	36
115 - 129	45
130 - 150	9

Correlations

96 De Anza boys

(VR/NA) to IQ -- r = .75
Rho Equation

GRADE POINT

Range	N
.5 - 1.4	7
1.5 - 1.9	14
2.0 - 2.4	18
2.5 - 2.9	21
3.0 - 3.4	23
3.5 - 4.0	11

Correlations

94 De Anza boys
(VR/NA) to G.P.
Rho Equation -- r = .87

SPACE RELATIONS

Range	N
0 - 29	8
30 - 59	23
60 - 89	35
90 - 99	26

Correlations

Hen-Nel IQ	r = .26
Lee-Thorp Algebra Aptitude	r = .47
Physics Marks	r = .15

ABSTRACT REASONING

Range	N
0 - 29	5
30 - 59	19
60 - 89	38
90 - 99	30

Correlations

(D.A.T. Manual, Seashore)
Hen-Nel IQ - - r = .52

Lee-Thorpe
Algebra Aptitude r = .57
Physics Marks r = .38

MECHANICAL REASONING

Range	N
0 - 29	8
30 - 59	25
60 - 89	39
90 - 99	18

Correlations

(D.A.T. Manual, Seashore)
Hen-Nel IQ - - r = .31

Lee-Thorpe
Algebra Aptitude r = .46
Physics Marks r = .47

VERBAL REASONING/NUMERICAL ABILITY

Range	N
0 - 29	0
30 - 59	10
60 - 89	46
90 - 99	37

Correlations

(D.A.T. Manual, Seashore)
(VR)/ Hen-Nel IQ - - r = .73
(NA)/ Hen-Nel IQ - - r = .70

Lee-Thorpe Algebra
(VR) - - r = .65
(NA) - - r = .77

Physics Marks
(VR) - - r = .59
(NA) - - r = .60

10th Grade Boys

I. Q. -------------- r = .75
Grade Point -------- r = .87

RECOMMENDED SELECTION CRITERIA BASED UPON SIGNIFICANT PATTERNS OF FREQUENCY, INTERCORRELATIONS OF CRITERIA, AND CORRELATIONS TO SUBJECT AREAS

I. Q.	105 to 119 (lower semi-quartile initial group)
G.P.	1.5 to 3.0 (College prep and gen. curric.)
VR/NA	60 to 89
S.R.	60 to 89
A. R.	60 to 89
M.R.	60 to 89

IMPLICATIONS OF THE STANDARD DEVIATION FACTOR WHEN GOING BEYOND THE RANGE OF ANY OF THE RECOMMENDED CRITERIA.

Before deviating from the recommended percentile bands for the D.A.T. criteria, we must take the following points into consideration:

1. Those students who ranked within or above the range on only one criterion, and who ranked below the minimum level on the other criteria should not be considered as average capable learners because of the relatively high correlation between D.A.T. sub-test percentiles and success in algebra and physics.
2. A student ranking within the range of one criterion and over the range on one or more others should be considered.
3. Before deviating from the recommended A.A.T. percentiles we should first consider going over the upper grade point limit of 3.0 by one standard deviation for the initial group of 96 10th grade boys.

   Recommended Grade Point --- 3.0
   Standard Deviation ---------- .63

   Criterion extended to -------- 3.63 G.P.

   This suggestion is made on the premise that an average learner can attain a high grade point through drive or interest while a student ranking within the 90-99th percentile band cannot be considered average.
4. Deviating from the recommended top I.Q. level is not advisable because of the 105-117 band corresponds to the lower semi-quartile range for the initial group. The standard deviation is 9.45, indicating that the 119 top limit is already 2 points into the upper semi-quartile range (117 to 128).

CURRICULUM MATERIALS

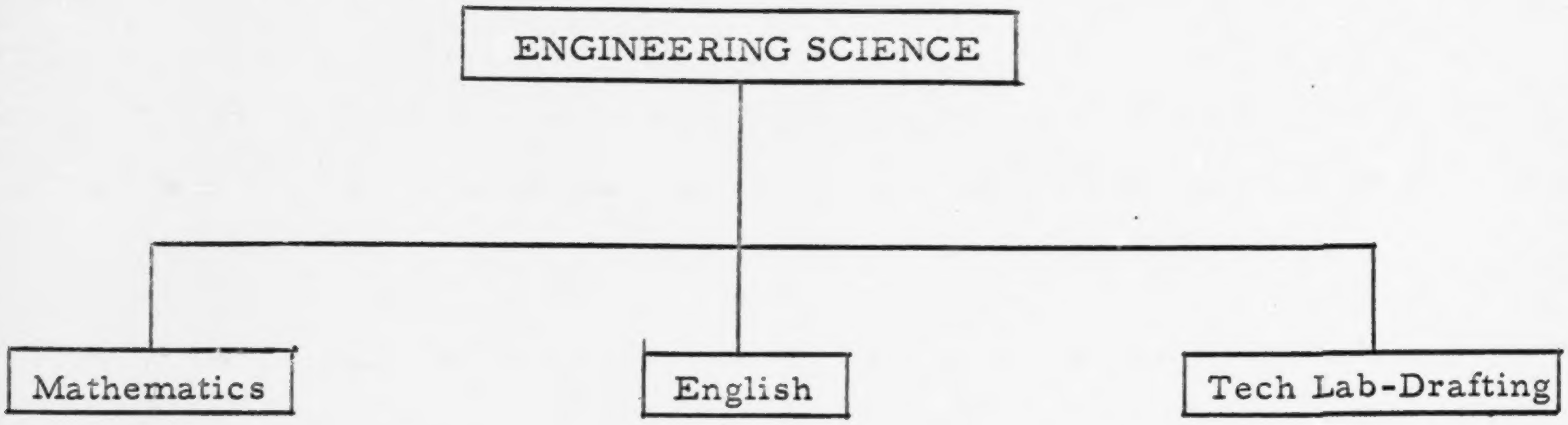
INTRODUCTION

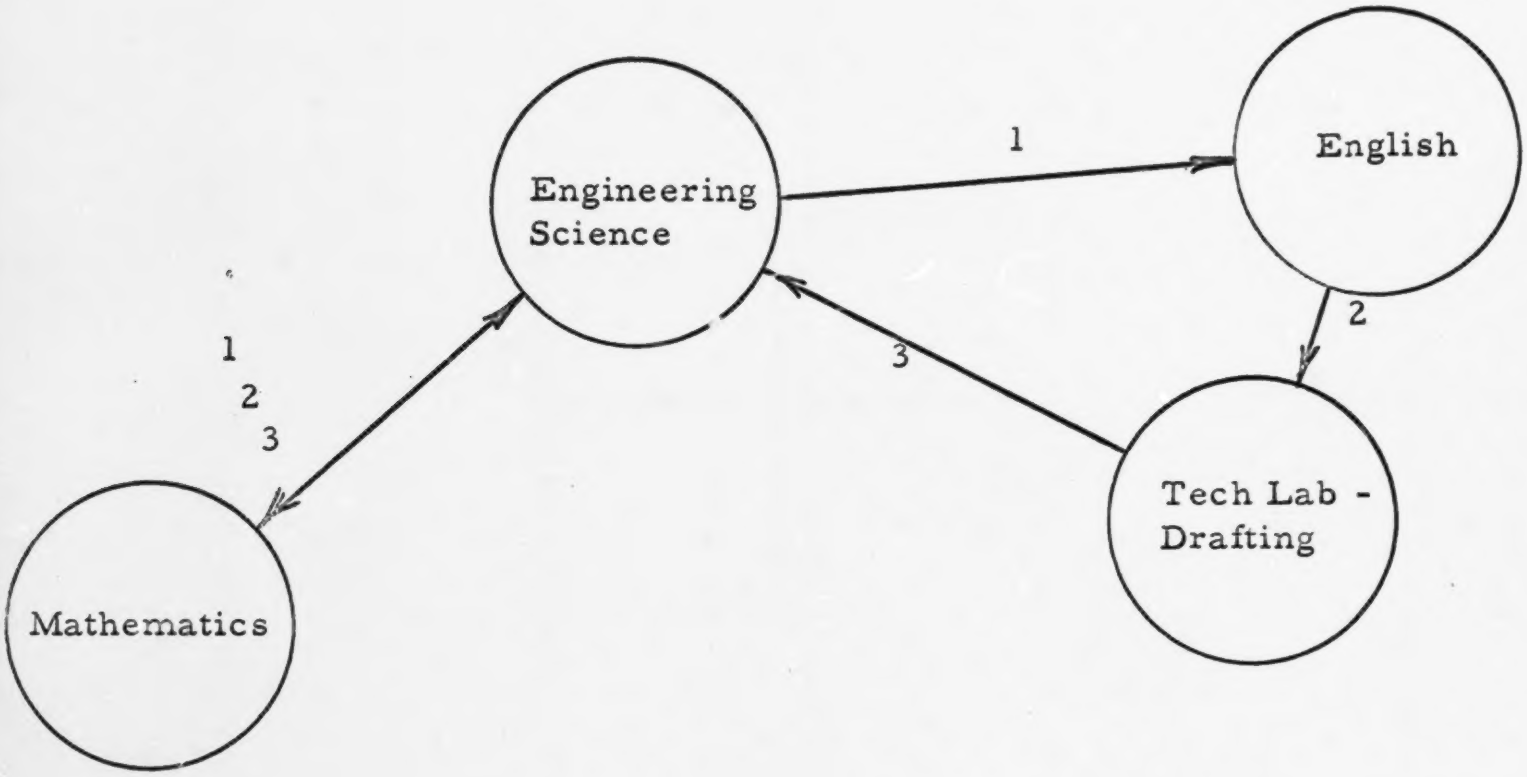
As we have repeatedly pointed out in our previous discussions of THE RICHMOND PLAN, the curriculum is developed around a team-teaching concept.

While there is one set of goals for the entire Richmond Program, it is interesting to note that there are two approaches to this problem. In one high school, the team is made up of members from the various departments, i.e. physics, mathematics, science, English and shop. In the other high school the industrial arts department has taken the responsibility of teaching each of these subjects. The key underlying course, however, for both high schools, is the physical sciences.

So that the reader can compare the differences in the techniques employed in each of the high schools, we have included in this report, examples from each of the programs, to show how the common goals are attained by the utilization of the talents available in each high school.

* * *





PROJECT FLOW CHART

HIGH SCHOOL PRE-TECH PROGRAM

	JUNIOR YEAR		SENIOR YEAR	
Period	FALL	SPRING	FALL	SPRING
1	Physical Ed.	Physical Ed.	Physical Ed.	Physical Ed.
2	U.S.History	U.S.History	American Gov't	American Gov't
3	Math	Math	Math	Math
4	English	English	English	English
5	Tech-Lab	Drafting	Drafting	Tech-Lab
	*	*	*	*
6	Physics	Physics	Physics	Chemistry

* SCHEDULED SO THAT 2 HOURS AVAILABLE IN SEQUENCE.

TECHNICIAN PROGRAM

Examples of Interrelation Between Departments

I. TITLE OF UNIT: HEAT

Topic I - Linear Expansion
Project H-1

Objectives:

(1) Be able to solve problems in heat relating to the co-efficient of linear expansion but excluding the bulk of modulus of expansion.

Math Requirements	Engineering Science Requirements
1. Ability to solve linear formulae such as: $\Delta L = \alpha (T_1 - T_2)$ $MS\tau = MST$	1. Objectives - to understand the following: a. First Law of Thermodynamics. b. How to solve problem using formulae and definitions. c. Observation and report writing the heat demonstrations involving the first law of Thermodynamics as performed by the instructor.
2. Understanding meaning and use of "delta"	2. Know the following definitions: a. Temperature b. Heat c. Co-efficient of Linear Expansion d. Co-efficient of Volume Expansion e. Thermal energy

Field trip applicable to project

(2) Be able to construct in the Technicians Lab a specified piece of apparatus illustrating some phase of linear expansion including necessary drafting, and concluding with a properly written report and an orally presented demonstration.

English Requirements	Tech. Lab - Drafting Requirements
1. Letter of transmittal to technical lab instructor.	1. Bridge model a. Purpose To illustrate linear expansion expansion of a bridge under temperature change.
2. English report of completed project including results of experiments	2. Model bridge is constructed and experiments performed as set forth in Sutton's Project #2, Heat Section
	3. Other examples of projects in Sutton involving heat are: H14, H17, H18, H19

PRE-TECH PHYSICS - - De Anza High School

STATEMENT OF PURPOSE

John Briscoe, Instructor of Physics at the De Anza High School makes the following statement: 'The underlying purpose of this physics course is to develop in the learner, an understanding of the basic laws of applied physics. No prior knowledge of the subject is required but prior learner knowledge gained from past experiences must be ascertained and utilized i.e. model railroad building, ham radio, hot rods, etc. Our American youth have had a liberal exposure to a high complex mechanical culture and they know 'how' things work. In order to become technicians, however, they must also know 'why' things work and be able to explain the 'hows' and 'whys' to others. Technical physics is not aimed at a broad exposure to concepts. It is developed to provide a discipline basis in the fundamentals of such engineering studies as mechanics, fluids, strength of materials, theory of machines and theory of structures. This course is concerned with fundamental laws, phenomena, and techniques of their application in calculation. In this regard, Tech Physics parallels the PSSC approach by attacking concept through measurement. However, the learner will not be exposed to the 'popular' items involving more advanced or specialized study.

The learner will be given clear concise problems treating the relationships of physical concepts and phenomena through realistic and timely projects based on actual 'boy-level' engineering situations. Tech Laboratory will serve as engineering proving ground where the learner will design, construct, operate and discuss devices familiar to him which exemplify the laws and phenomena being studied. Close integration with the mathematics program in The Richmond Plan is a vital part of Technical Physics, but it is not required that the learner have an extensive knowledge of advanced math as is the case in the traditional physics. Basic algebra, geometry and trigonometry will be developed as a background in both the mathematics classes and in the physics laboratory concurrently as the courses progress. As an example, slide rule proficiency will be developed in an early unit in mathematics, thus providing the learner the opportunity to solve laboratory and shop problems more rapidly and to increase his reliance upon the slide rule. A unit covering numerical trigonometry (right triangle functions) is presented in the physics class as a preface to the study of mechanics.

"Each topic presented in the physics course has been time sequenced to coordinate physics, laboratory experiments, with tech laboratory projects. Projects will include the design and construction of demonstration equipment with which the learner will be expected to demonstrate his understanding of the physical principles involved. Each topic includes a set of model problems with worked out solutions. These model problems follow a logical approach to examples familiar to the learner, covering every significant point of theory he is expected to learn. Answers are given along with the problem, thus offering the learner the opportunity to check his results immediately. The discipline of checking results is one which the learner will consistently be encouraged to develop. Line drawing technique is another important adjunct to the physics course. In all units where such sketches can be used, the learner will be required to supplement his solutions with lined drawings. With carefully checked computations and clear sketches, the student will have a firm basis for developing written and oral reports in his English classes and physics laboratory. All reports written on experiments and projects will be done as part of the English classwork, but the reports must also be submitted to the physics teacher who will evaluate them for technical validity. Vocabulary lists prepared from the materials for each unit have been prepared for the English instructor whose responsibility will be to instruct the learners in parts of speech, sentence structure and spelling. The technical reports written by the students will provide evidence of improvement in communication skills for the need for further instruction."

In the curriculum outlines which will follow, it is interesting to note that the De Anza approach is based on developing the concepts of the physics from a point of view of measurement of physical phenomena. Beginning with a simple unit in measurement, measuring a quantity called "length," the learner is introduced to each of the concepts of mechanics, thermodynamics, hydraulics, etc., from the point of view of measurement. For example: the quantity called "length" is developed to a measurement of mass, to a measurement of time, to a measurement of pressure, to a measurement of temperature, etc. throughout the entire course in the year and a half of physics.

Carefully selected examples of the technical physics course outlines follow.

EXAMPLE OF "WORK ORDER" GIVEN TO STUDENTS

Comment:

Student John is one of the very capable students and has displayed a very deep interest. The boys whose names appear at the bottom of the list include two of the most shy pupils. The purpose of this "gimmick" is to encourage the development of innergroup relationships between the "brains" and the "doers."

TO: John Doe
FROM: Mr. Briscoe
SUBJECT: SPECIAL EXPERIMENT

As a follow-up on the interest you displayed in the result of your first experiment with friction, I want to urge you to carry on your work into the field of "TENSILE STRENGTH"--

Your next assignment is as follows:

(1) Refer to page 71 in your workbook and adapt your apparatus to make a fairly sensitive "WIRE BREAKING MACHINE."

(2) Check with Mr. Craig about making the necessary parts in the TECH LAB.

(3) When your device is ready, carry out Experiment #15 and then make any necessary improvements your machine may need.

(4) I will rely upon you to seek out the factual information necessary to understand and explain the operation of the machine and train the other class members in its use when they are ready for experiment #15.

(5) I suggest that you choose a working partner who is pretty sharp in shop work so you will be able to move faster toward completion of the assignment.

Good men are:

Claude Brown
Jack Smith
Mes Byrne

Peter White
Gary Anderson
John Doe

INSTRUCTIONAL UNIT INTEGRATION CHART

Science	Tech Lab	Algebra	English
1. Sept-Dec 14 Measurement of Physical Phenomena	Measurements	Slide Rule	Language Fundamentals Oral Expression
2. Theory of Machines Jan 3-Feb 30	Fundamentals of Machines Safe Operation Economical Operation	Simple Equations	
3. Mechanics March-May 30		Numerical Trig & Complex Fractions	Technical-Report Writing
4. Sound & Wave Motion June 1-14	Construction Inspection Testing Engine & Machine Noise analysis & Correction	Functions Graphs	Technical Reports

A TECHNICIAN LEARNS TO MEASURE - "If a thing exists, it can be measured."

The ability to make measurements, to use data in calculations, and to draw conclusions from them, is a distinguishing characteristic of the technician. He must begin now to develop skills with measuring instruments and the use of standard systems of measurement with which a technician works.

Instruments enable the scientist and the craftsman (the technician is both) to measure that which he needs to know in order to perform his experiments, tests, and jobs. Along with learning how to use measurement devices, the student is also taught why they work and how to convert his measurements into language. The world of the technician is not a picture-book world. It is a world of ideas that must be developed and explained. It is no place for a person with a "stay-at-home" mind. He must go after those words and learn how to use them well, because only with words, can he put his ideas across.

In measurement we encounter many words and phrases that tell the state of the substance measured, the degree of accuracy achieved, and the tolerance established. This is true of any measurement that the student will make.

The most important thing for the student to remember about this phase of work is that what he learns now will determine pretty much what kind of technician he will become. The graduate technician has only himself to sell when he applies for a position. He isn't chrome plated; he doesn't have fins; but the very best technician does have skills and he knows how to use them. He is now to begin designing the most important product he will ever develop - HIMSELF. The best place to start is with the instruments that he will have to master.

"It is possible to determine the height of
a tree without having to climb to its top."

UNIT: MEASUREMENT

TOPIC: MEASURING THE QUANTITY CALLED LENGTH

OBJECTIVES:
(1) To gain skill with micrometers
(2) To gain skill with vernier calipers.
(3) To gain skill recording measurements.
(4) To read Metric and British linear unit scales
(5) To explain the limitations and (or) advantages of each system as determined by these projects.

PROJECTS:

1. Measure the diameters of 100 uniform coins and record the dimensions on a Standard Data Sheet.

2. Measure the nominal length (inside) of 100 paper clips. Record the dimensions in both Metric and British units on a Standard Data Sheet.

3. Lay out a Cartesian Graph having the x axis 1/10mm units and the Y axis in 1/16 inch units. Plot the relationship of the systems.

   Do your work on a Standard Data Sheet.

OBJECTIVE OPERATIONAL BEHAVIOR CHANGES TO RESULT FROM LEARNING IN A UNIT ON "SCIENTIFIC MEASUREMENT" TAUGHT AS PART OF TECHNICAL PHYSICS

1. THE LEARNER CAN MEASURE:

    1. Temperatures
    2. Volumes
    3. Distances
    4. Weights
    5. Pressures
    6. Times

2. HE CAN IDENTIFY FACTORS THAT EFFECT ACCURACY SUCH AS:

    1. Method used
    2. Skill in use of instruments
    3. Reliability of instruments
    4. Degree of project definision

    NOTE: Of the above factors, "Degree of project definition is dominant."

3. HE CAN DEFINE AN EXPERIMENT OR PROJECT IN TERMS OF AN "ACCURACY ESTIMATE" AND SUPPORT HIS CONCLUSIONS IN AN ANALYTICAL WAY WITH:

    1. Data
    2. Calculations
    3. Diagrams
    4. Specifications
    5. Reports

UNIT: MEASUREMENT

TOPIC: MEASURING THE QUANTITY CALLED LENGTH

PROJECT: "MEASURE THE DIAMETERS OF 100 UNIFORM COINS"

OBJECTIVES:

1. To set up an inspection project.
2. Determine the degree of accuracy required.
3. Select the appropriate instrument.
4. Practice to develop reliable performance with a precision instrument.
5. Organize data to serve as a basis for a project report.

APPARATUS:

1. 1 set of 1pp uniform coins.
2. 1 Micrometer (0 to 1 in.)
3. 1 Vernier Caliper (inch and metric).
4. 1 Standard Data Sheet.
5. Sharp pencil.
6. Work table cover sheet.

PROCEDURE:

1. Inspect the coin for damage or irregularities.
2. Pick a "random set" of coins and measure each with the Vernier caliper and then with the micrometer.
3. Select the instrument that will meet the degree of accuracy called for in this project.
4. Practice measuring a single coin until your readings show some degree of reliability.
5. Proceed to measure each coin carefully recording each size as you obtain it.
6. Analyze your Data Sheet and decide how best to arrange your results to demonstrate the distribution of the the dimensions.
7. Prepare a table or graph, whichever you decide is best for understanding and explaining the project.

UNIT: MEASUREMENTS - Test to Accompany Project ML

TOPIC: MEASURING THE QUANTITY CALLED LENGTH

FACT #1 You discovered that one system of measurement had a distinct advantage over the other for the "COIN INSPECTION PROJECT."

QUESTIONS:

1. What system did you select? ____________________
2. What instrument proved best? ____________________
3. What degree of accuracy was required? ____________________
4. Was your instrument calibrated fine enough? ____________________
5. Where could error creep into this kind of project? ______
   ____

FACT #2 You spent considerable time setting up and carrying out this inspection project.

QUESTIONS List in order of importance the things you learned must be done whenever you do this kind of work.

1. ____________________
2. ____________________
3. ____________________

What does your text book have to say about the importance of what you listed above?

List those things you already knew that made possible your being able to complete every phase of this project. (f you learned something in Tech Lab or in Math that helped here, list that too.)

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________

FACT #3 There are several items of specific information that you should have learned from this project. See if you can answer the following questions:

1. The basic quantity you measured was __________________

2. The dimension you used was __________________

3. To measure this close, you need a __________________

4. What two conditions determined the degree of accuracy for this project?
   (1)____
   (2)____

5. Would it have been more practical to carry the project to a higher degree of accuracy?
   (1) Explain__________________________________
   (2) What instrument would you use to obtain finer measurements?__________________

REMEMBER

As a general rule, the result of an experiment or project cannot be more accurate than the least accurate number in your set of dimensions.

FACT #4 In learning to measure, the technician also learns how to organize measurements and calculations so they can be reported.

QUESTIONS

1. Limits to accuracy of a report are determined by which of the following:

   (1) the materials measured
   (2) the instruments used
   (3) care in recording data
   (4) number of significant figures in the calculations
   (5) the degree of project definition originally established
   (6) the length of the slide rule used

2. When it is your job to conduct a project, who is the first person you should satisfy with the results?__________

3. A problem is never solved until you have checked your work for __________________________.

4. The best way to visualize quantities is to plot them on a ____.

REMEMBER: You have learned that a measurement is a number of dimensional units. In mathematical calculations, both the number and the unit must be included. This helps to keep the units correct and, if the calculations are properly done, will prove mathematically that your answer is in the right unit or combination of units.

UNIT: MEASUREMENT

TOPIC: MEASURING THE QUANTITY CALLED LENGTH

PROJECT: "MEASURE THE NOMINAL LENGTH (INSIDE) OF 100 PAPER CLIPS."

OBJECTIVES:

1. To repeat the process of setting up an INSPECTION PROJECT.

2. To witness the effect a CHANGE IN THE NATURE OF THE MATERIAL has upon the degree of project accuracy.

3. Selection of an appropriate instrument.

4. Actual experience comparing METRIC units to ENGLISH units.

APPARATUS:

1. 1 set of 100 uniform paper clips.
2. 1 pocket scale (Metric & English).
3. 1 Vernier Caliper (Metric & British).
4. 1 Standard Data Sheet.
5. Sharp pencil.
6. Work table cover sheet.

PROCEDURE:

1. Inspect the items for damage and distortions.
2. Pick a RANDOM SET of clips and measure each of the clips with the pocket scale, then the Vernier Caliper.
3. Select the instrument which you can meet the degree of accuracy called for in this project.
4. Practice with the instrument until your readings are consistent.
5. Measure each clip carefully.
   USE BOTH METRIC AND ENGLISH UNITS.
6. Record your dimensions as you obtain them.
7. Organize the DATA in such a way that you can show by a NORMAL CURVE the degree of uniformity obtained from the manufacturing process.

INCORPORATE INTO THE GRAPH BOTH METRIC AND ENGLISH UNITS.

UNIT: **MEASUREMENTS -** Test to Accompany Project ML^2

TOPIC: MEASURING THE QUANTITY CALLED LENGTH

FACT #1 You compare units of the METRIC SYSTEM to units of the ENGLISH SYSTEM.

QUESTIONS:

1. Which system is easiest to work with? ____________________
   List three reasons:
   (1) ____
   (2) ____
   (3) ____

2. Which is smaller, a millimeter or 1/32nd of an inch?
   ____
   Show by an Equation:
   ____

3. Will the above equation hold true for the relationship of all Units of length in each system?
   ____
   (1) Show the relationship of 1/16th to one millimeter.
   ____
   (2) Show the relationship of one inch to one centimeter.
   ____

FACT # 2 In the PAPER CLIP PROJECT, you selected a Vernier Caliper over a pocket scale.

QUESTIONS:

1. What is the main advantage of the caliper over the scale?
   ____
   ____

2. What additional advantage does the VERNIER SCALE offer?
   ____
   ____

3. Compare VERNIER CALIPER readings to MICROMETER readings:

   Vernier (in.) ______________________________
   Vernier (mm) ______________________________
   Micrometer (in.) ____________________________
   Micrometer (mm) ____________________________

FACT # 3 Comparing the DEGREE OF ACCURACY of the "PAPER CLIP PROJECT" to the "COIN INSPECTION PROJECT," you found that sizes were expressed in different terms.

QUESTIONS:

1. What one term expresses the DEGREE OF ACCURACY required for the COIN INSPECTION PROJECT?

   ____

2. What is the term that expresses the DEGREE OF ACCURACY of the PAPER CLIP PROJECT?

   ____

FACT # 4 You were expected to collect data in the "PAPER CLIP PROJECT" from two systems - Metric and English. Most scientific work is done in the Metric system while most manufacturing work is done in the English system.

QUESTIONS: Let's see if you can associate what you learned to other problems:

1. The bore of a foreign car is stock at 57mm and the stroke at 73mm. What are these sizes in English units?

   ____

2. Your English cylinder gauge shows the cylinders are tapered .006". What Metric Diameter will just true up the cylinders? ______________________________

3. You now have to turn the outside diameters of a set of pistons to fit the re-bored cylinders. If you must have the equivalent of .006" clearance, what will the new Metric diameters be? ______________________________

REMEMBER: You have experimented with the quantity called LENGTH. The things you have learned about degree of accuracy, project definition, the characteristics of the two systems, and the usefulness of data will be important to you as long as you do technical work. If you are still not certain about any aspect of this unit, let's go through it again.

A THING HALF LEARNED IS ALREADY HALF FORGOTTEN.

UNIT: **MEASUREMENT**

TOPIC: GAUGES AND GAUGE DESIGN

LESSON: THREE-WIRE SYSTEM OF MEASUREMENT

This system has been developed for the accurate measurement of thread gauges. The pitch diameter is defined as the diameter of an imaginary cylinder whose surfaces pass through the thread at a point where the width of the tooth is equal to the space. This makes an ideal point of measurement because it is least affected by any variation in the angle of the thread. Special wires accurately ground to a size that will touch the side of the threads at exactly the right point are known as "best size wires." An article covering technical information about "best size wires" is found in the American Machinist's Handbook, page 58.

The machines used for making three-wire measurements have an accuracy of 0.0001 inch. The measurements are usually made in an air-conditioned room in which the temperature is maintained at 68° F. The tolerance of the wires is held to 0.00002 inch. The contact pressure is important. For pitches finer than 20 threads per inch, a pressure of 14 to 16 ounces is used. For pitches of 20 threads per inch or courser, a pressure of 2-1/4 to 2-1/2 pounds is used. It must be understood that this system is not used for the routine inspection of threads, but only for checking master gauges.

The general formula for determining the pitch diameter is as follows:

$E = M + (\cot a/2n) - G\ (\text{co } 1 + \text{cosec } a)$

in which

E = pitch diameter

M = measurement over wires

a = one-half the included angle of the thread

n = number of threads per inch

G = diameter of wires

PROBLEMS

A special screw is being checked by the three-wire method. The major diameter is 4.000 inches. The minor diameters is 3.6700 inches and the angle of the thread is 50°. There are six threads to the inch. Solve the general formula.

$$E = M + \cot a/2n \times G - (1 + \operatorname{cosec} a).$$

UNIT: MEASUREMENT

TOPIC: GAUGES AND GAUGE DESIGN

LESSON: CRITERION INSTRUMENT

PROBLEMS

1. List four prominent manufacturers of gauges used in volume production measurements.

2. Name the types of gauges used for checking screw threads.

3. Which would you specify for checking the internal diameters of an automobile cylinder block with a nominal diameter of three inches; a plug or a ring gauge?

4. In your own words, explain the principles of the Go-notGo gauging methods. Write up a list of gauges that can be used for this type of inspection.

5. Sketch the moving part system of a dial indicator. Name the parts and explain their function.

6. How can the effects of friction and inertia best be reduced in a magnification mechanism for an indicator gauge?

7. Describe an automatic gauging mechanism and explain how this type differs from a combination gauge.

8. List the advantages of an optical comparator when used for the rapid checking of screw threads.

9. A screw threadwas checked by means of a comparator. The shadow of the thread was displaced laterally from the master outline. What error in the work piece did this condition indicate?

UNIT: **MEASUREMENT**

TOPIC: GAUGING AND GAUGE DESIGN

LESSON: FOUNDATION INFORMATION

Modern manufacturing requires an extensive employment of gauges for shop work, inspection, and standards of reference. Technicians are expected to understand how gauges are designed, constructed, used, and checked.

A gauge is defined as a device for investigating the dimensional fitness of a part for a specific function. It also defined as a process of measuring manufactured materials to assure the specified uniformity of size and contour required by the industries.

Special gauges are generally designed for the purpose of checking quickly the dimensions of work pieces being manufactured in large quantities. There is an increasing demand on manufacturers to produce items to closer and closer tolerances on mating parts, a practice which places great importance upon gauging. One of the overriding requirements for the design of gauges is that of saving time. Gauges need not always be elaborate devices but they must be accurate, as free from trouble as possible, and simple to use and adjust.

CLASSIFICATION OF GAUGES

There are many types of gauges, but they can all be place in one of three broad groups, namely:

(1) fixed size gauges
(2) indicating gauges
(3) combination gauges.

Fixed gauges are the most common and are used for large and small production. Many of the gauges used in industry today are manufactured by instrument companies, but the technician is also called upon to design and make some special gauges.

UNIT: **MEASUREMENT**

TOPIC: TEMPERATURE

1. Thermometric Scales

Our common temperature scales were developed by assigning numerical values to the melting point of ice and the boiling of water at standard atmospheric pressure.

The centigrade scale designates the ice point as 0° C and the boiling point as 100° C with a fundamental interval of 100°.

The Fahrenheit scale designates the ice point as 32° F and the steam point as 212° F, with a fundamental interval of 180° F.

If we add to the Centigrade scale the absolute temperature of the ice point, 273.16, we obtain temperature measurements of an absolute scale called KELVIN. Temperatures on the Kelvin scale are designed as $^\circ$K.

The absolute temperature on the Fahrenheit scale, measured in Fahrenheit degrees is 459.69.

If this number is added to Fahrenheit temperatures we obtain readings on the absolute RANKINE scale, designated as $^\circ$R.

In general expressions, absolute temperature will be denoted by capital T, while temperatures on the general or common scales will be denoted by a lower case t.

Temperatures intervals or differences will be denoted by the Greek letter Θ

For the definition of a perfect gas as one that follows the relation

$$PV = RT$$

where R is constant, it, will be noted that the pressure P is directly proportional to the absolute temperature T for the constant volume of gas and that the volume V is inversely proportional to the absolute temperature for a constant pressure process.

This gives us experimental methods for approximating the absolute temperature scale, since some real gases behave very closely to a perfect gas.

Gas thermometers have been used in both the constant volume and constant-pressure types.

The constant volume type is favored for precise work.

The general scheme is to standardize the thermometer at the ice point and the steampoint and then determine the temperatures of certain fixed points, as the boiling point of melting points of certain pure substances, on the termodynamic scale. These fixed points are then used to calibrate other types of thermometers.

The gas thermometer is a precise means of measuring temperature. It involves skill and painstaking corrections, so that its use is confined to the national standardizing laboratories.

2. Expansion Thermometers

In general, all substances expand with the increase of temperature, although there are abnormal exceptions to this rule. Practical thermometers have been devised utilizing the linear expansion of solids and the volume expansion of liquids and gases.

It must be noted that expansion thermometers operate on the differential expansion of two different substances. Thus, in a bi-metallic thermometer, the measured variable is the difference in expansion between two solids. In a liquid-in-glass thermometer and indication is of the difference of expansion between the liquid and the containing glass.

3. Mercury-In-Glass Thermometer

The most commonly used instrument for measuring temperature. The lower limit of a MIG thermometer is the freezing point-38F of mercury. For temperatures up to 500° normal glass is used. For temperature up to about 950 F. borosilicate glass is used.

Magnitude of mergent stem error is

$$t_e = \frac{D\,(t_i - t_s)}{11{,}000 - D} \quad {}^{\circ}F$$

Every glass thermometer used for important test data will have an ice point indicated on the stem. This will permit a quick check in ice which will disclose bulb volume changes.

4. Low-Temperature Glass Thermometers

Contain Ethyl alcohol	-140°F	+ 175°F
Pentane	-203°F	+ 97°F
Toluene	-134°F	+ 231°F

5. Beckmann Thermometer

Special form of MIG thermometer particularly useful with fuel calorimeters. The novel feature of the Beckmann is the provision for changing the effective amount of mercury in the thermometer system by temporarily storing the excess in a reservoir at the top of the thermometer.

6. Bi-Metallic Thermometers

Principally used in thermostatic controls. Its speed of response is about the same as the MIG. Stem conduction error somewhat troublesome.

7. Pressure Thermometers

If a fluid is confined in a closed system, its pressure will be a function of the temperatures. The temperature can thus be indicated in Bourdon type pressure gauge.

Liquids, gases, and vapors are all used in pressure type thermometers.

In the general design, the fluid bulb is placed in the liquid whose temperature is to be measured. A capillary tube connects the bulb to a pressure gauge, which is graduated with a temperature scale.

Pressure-gauge thermometers are seldom used in experimental work but are widely used as operating instruments in permanent installations.

Disadvantages and limitations are high ambient temperature error, Elevation error, and thermal lag because of large bulb size.

8. Gas-Filled Thermometer

A gas thermometer is a fundamental instrument for measuring temperature in standardization work of high precision.

The gas thermometer is considered a constant-volume system.

Changes in ambient temperature affecting the capillar and gauge produce troublesome errors.

The range of a gas filled thermometer is limited by the pressure and corresponding stresses.

Nitrogen is commonly used in commercial gas-filled instruments which are used for temperatures up to 1200 degrees F.

9. Liquid-Filled Thermometer

Usually mercury is used in these systems, although alcohol and other organic liquids are advantageous for narrow ranges because of their high thermal coefficient compared with that of mercury.

The same considerations concerning the effect of ambient temperature changes on the line and gauge that apply to other types of instruments also apply to the liquid-filled thermometers. In fact, the effect is usually greater in the liquid-filled because the bulb is smaller.

10. Vapor-Pressure Thermometer

The relation between vapor pressure and temperature of a pure volatile substance is useful for measuring temperature.

The temperature is roughly a logarithmic function of the pressure in the form

$$P = a - b/T$$

so that the scale of a vapor-pressure thermometer will not be linear.

Suitable fluids for vapor-pressure systems are listed in a manner showing their approximate limits of usefulness:

Fluid	NPB, °F	t_c, °F
Water	212	705
Ethyl alcohol C_2H_5OH	172	470
Freon 113, $C_2Cl_3F_3$	118	400
Sulfur dioxide, SO_2	14	315
Ammonia NH_3	-28	271
Helium He	-452.0	-450.2

11. Resistance Thermometer

The electrical resistance of pure metals generally increases regularly with increase of temperature. Since measurements of electrical resistance can be measured with high precision by bridge methods, this is probably the most precise and practical method for measuring temperature within its range, especially since the platinum resistance thermometer is used to define the International Temperature Scale from the oxygen boiling point (-182.970 C) to the freezing point of antimony (650.5 C).

12. Thermistors

Temperature-sensitive ceramic resistors which can be used as resistance thermometers. The material consists of a sintered combination of ceramic material and a semi-conducting metallic oxide. Thermistors have a very high negative temperature coefficient of resistivity.

In contrast to a metallic resistance, the resistance of a thermistor becomes much larger as the temperature is lowered. The resistance in ohms is a logarithmic function of the Kelvin temperature of the form

$$\text{Log}_{10} R = A + B/(T + C)$$

Thermistors provide an extremely sensitive method for detection of temperature changes. Readings may be expected to be consistant within 0.01 Cw.

13. Resistance Thermometer Bridges

An ordinary Wheatstone bridge may be used with a resistance thermometer. However, since the range of resistance to be covered is relatively small, specialized thermometer bridges of greater convenience and higher precision are usually used.

The possible errors in the bridge circuit are those due to:

(1) Contact resistance in the switch

(2) Thermoelectric emf at the junctions of dissimilar metals.

(3) Resistance changes due to temperature changes of the measuring resistors.

Resistance coils in bridges are usually made of manganin wire, which is an alloy of (65 Cu, 30 Mn, 5 Ni) having a very small termperature coefficient of resistivity at room temperature range.

14. Thermoelectric Thermometers

At the junction of two dissimilar metals ther is an emf known as the Seebock effect which is a function of temperature. If the circuit is closed by another remote junction of the two conductors, another opposing emf exists at the other junction. If these junctions are at the same temperature, the emf's are equal and opposite and no current will flow.

However, if one junction is at a higher temperature, the emf at the hot junction will exceed that at the cold junction, and a current will flow, which is dependent on the resistance of the circuit.

The electric energy is derived from an absorption of heat at the hot junction and a rejection of heat at the cold junction, so that the device is a thermodynamic engine for the conversion of heat to electrical work.

The operation is also reversible in the sense that if a current is forced through the circuit by a battery, heat will be absorbed at the cold junction and rejected at the hot junction. Under these conditions the device functions as a refrigerator or heat pump. This phenomenon is known as the Peltier effect.

From thermodynamic reasoning, Lord Kelvin showed that the interrelation of the Seebock and Peltier effects should lead to a linear relationship between temperature difference and emf. He postulated and demonstrated that there must be an emf developed in a single homogenous conductor whose ends are at different temperatures. This Thompson effect is associated with the thermal conduction of heat from the hot end of the conductor to the cold end.

The thermodynamic theory indicates that the functional relationship between temperature difference and emf e should be in the form

$$e = a\theta - b\theta^2$$

which is actually quite close for pure metals. However, the agreement is not nearly so good for the alloys commonly used for thermocouples.

If a third metal is introduced into the circuit, it may have both of its end connected to the original metals. If the new connections are the same temperature, equal and opposite emf's will be developed, and there will be no change from the electrical condition of the original circuit. If the new intermediate metal joins the original pair, it is still true that the net emf is not effected if its ends are of the same temperature. The proof of this statement involves reasoning based on the second law of thermodynamics. This fact is know as the "Law of Intermediate Metals." It allows us to use measuring instruments of copper, for instance, with couples of any materials.

15. Thermocouple Materials

There are many combinations of metals that can be used for thermocouples, but only a few are commonly used where accuracy and durability are required. The requirements include

(1) A high coefficient of thermal emf with temperature
(2) Continuously increasing relation of emf to temperature over a long range.
(3) Freedom from phase changes or other internal phenomena giving rise to discontinuities in the temperature-emf relation.
(4) Resistance to oxidation or contamination.
(5) Reproducibility

16. Millivoltmeter Pyrometer

The emf developed in a thermocouple circuit may be measured by a D'Arsonval d-c electric indicating meter. The meter is basically a current indicator or ammeter, since its deflection is proportional to the ampere-turns developed in the moving coil. The current flowing through the circuit is directly proportional to the emf developed by the thermocouple, but it is also inversely proportional to the resistance of the circuit.

UNIT: FUELS FURNISH ENERGY FOR MACHINES

What is the cause of a "gas knock" or "ping?"

Why is high octane gas so good?

What is the real meaning of the notice, "this gasoline contains lead?"

TOPIC: WHAT IS THE CHEMISTRY OF COMBUSTION?

1. The Nature of Matter

The atomic theory -- Textbook - Periodic table

The molecules -- Nature of molecules - How they are built

Elements and compounds

Mixtures and compounds

Physical and chemical changes -- Demonstrations - Experiments

2. Conditions for Combustion

Definition of combustion
Process of combustion

Ignition temperature
Demonstration and experiments

Kindling temperature
Demonstration and experiments

Flash point
Demonstration and experiments

Turbulence
Secret of fuel-air mixture

UNIT: **FUELS FURNISH ENERGY FOR MACHINES**

TOPIC: CRITERION INSTRUMENT

COMPLETION SUMMARY

1. Molecules are made up of__________ which in turn are made up of__________

2. The atoms of an ______________ are all alike.

3. A____________ is composed of two or more kinds of atoms.

4. A_____________may be made in many proportions.

5. A change that permanently alters the molecules of a substance is called a _______________ change.

6. When fuels burn they unite with the _________ of the air.

7. __________ temperature has to do with lighting a fire: the ___________ with the amount of evaporation.

8. Ease of ignition depends upon the __________ temperature and upon the ______________ of the particles of the fuel.

9. A mixture of air and some dusts, vapors, or gases may burn very rapidly. This kind of combustion is called an ________________.

10. Road dust will not form an ________ mixture because it will not burn.

11. Mixtures are usually too __________ or too _________ to explode.

12. Gasoline is derived from _________ which is a ________ of liquids.

13. Crude oil is separated into various liquids by ____________distillation.

14. Gasoline made by breaking down large molecules is called____________ gasoline; if made from lighter molecules it is called_______________ gasoline.

15. ____________ is an important quality of a good gasoline.

16. The two chief impurities that must be removed from gasoline before they are suitable for use in engines are __________ and ____________.

17. Hard carbon may form in an engine from the use of a gasoline or oil containing ____________________.

18. Gasolines that burn too ________________ cause a knock.

19. Spontaneous ignition of a gasoline-air mixture due to compression results in the ______________ of the mixture.

20. Knocking ______________ the power of an engine and _____________ its temperature.

21. The____________ number of a gasoline is a measure of its antiknock qualities.

22. ___________ is used instead of gasolines in some tractors.

23. Benzol is sometimes mixed with _____________ for use as a fuel for engines.

24. Alcohol may be mixed with ____________ for operating automobiles.

25. The three principal products of combustion in an engine are ___________, _____________________, and _______________.

EXERCISES

1. What evidence have we that gasoline is a compound?

2. Rubber dissolved in naptha to form rubber cement. Give any evidence you may find to show that this cement is a mixture and not a compound.

3. Is fractional distillation a chemical change? Why?

4. What kind of change occurs in the cracking of kerosene?

5. The flash point of propane is below zero F. Why can you not light it with a piece of ice?

6. When you blow on a fire you increase the supply of oxygen and the fire burns brighter. Why can you blow out a match?

7. Why is paper such a good material for starting fires?

8. Why are explosions of dust mixtures less frequent than those of gas mixtures?

9. Why is the use of kerosene not as hazardous as the use of gasoline?

10. Which is more likely to form an explosive mixture, kerosene or alcohol? Explain.

11. Why will an engine not operate well on a "rich" mixture. Why will it fail to operate when flooded?

12. Give three reasons why alcohol is not more generally used as a fuel in this country.

13. Mention some reasons why alcohol may be used in increasing quantities in the future.

14. What is fuel oil?

15. Why is fuel desireable for use in ships?

16. What kind of engines are operated on fuel oil?

17. Why is water gas cheaper than coal gas?

THE AUTOMOBILE EMBODIES MANY PRINCIPLES OF MACHINES

1. What is the function of the frame?

2. Of what value are springs and shock absorbers?

3. How is friction overcome and used in automobiles?

4. What are the principal parts of the power plant?

5. What are the parts of the power plant?

6. What are the parts of the fuel system?

7. How are combustion, convection, and radiation used in an automobile?

8. What simple machines are used in the automobile?

9. How does the transmission system operate?

UNIT: **THE AUTOMOBILE EMBODIES MANY PRINCIPLES OF MACHINES.**

When, if ever, do the wheels of an automobile turn faster than the engine?

Why are the rear wheels mounted on separate axles?

Are four cylinders enough to furnish a continuous torque on the crankshaft?

TOPIC: WHAT IS THE FUNCTION OF THE FRAME?

1.	Kinematics of the Frame --	Experiments with members and complete frame models
2.	Moments of Force -------	What is a moment of force? What force moments must the frame counter? How does the frame design effect the operation of the car?

UNIT: THE AUTOMOBILE EMBODIES MANY PRINCIPLES OF MACHINES

TOPIC: OF WHAT VALUE ARE SHOCKS AND SPRINGS?

1. Springs Absorb The Inertia of The Car

Meaning of inertia.
Elasticity and Hooke's Law.
Impace and spring design.
Force and spring demans.

Testing and compression of an auto spring (Leaf type).

2. Shock Absorbers Overcome Oscillations

Meaning of oscillation.
Principles of shock absorbers: Fluid
Mechanical

Action of shock and fluid viscosity.

3. Knee-Action

Coiled springs and Hooke's Law.
Springs and "rebound."
Knee-action linkage systems.
Springs, Linkage, and Shocks:

How they combine to maintain stability,
offset moments of force, and
control wheel geometry

Calculate magnitude of forces exerted by rebound of auto front-end.

Determine work done by shock absorber to check rebound.

UNIT: THE AUTOMOBILE EMBODIES MANY PRINCIPLES OF MACHINES

TOPIC: HOW IS FRICTION OVERCOME AND USED IN AUTOMOBILES?

1.	Roller Bearings - -	Dynamics of, Where used, What they eliminate Load carrying capacity of.
2.	Lubrication --	Nature of oil, Nature of grease, Friction reduction study.
3.	Ball Bearings - -	Dynamics of, Where used, What they eliminate, Load carrying capacity.
4.	Friction and Machine Surfaces - -	Surface conditions, Surface clearances, Lubrication specifications, Friction and heat.
5.	Useful Friction - Tires, Brakes, and Clutch - -	Determination of magnitude of friction: (1) In clutch (2) In tire (3) In Brake (one wheel)

UNIT: THE AUTOMOBILE EMBODIES MANY PRINCIPLES OF MACHINES

TOPIC: WHAT ARE THE PRINCIPLE PARTS OF THE POWER PLANT?

1. The Four-Stroke Cycle Engine

Study of Otto Cycle cylinder diagrams.
Experiments gathering engine data:

(1) Compression radio
(2) Cylinder pressure
(3) Fuel-air mixture
(4) Combustion pressure

EXPERIMENT:

Design and demonstrate a model (using lab equipment) to show the operation of an internal-combustion engine.

2. Multi-Cylinder Engines

Purpose of: Overlapping power impulse.

Study of power stroke sequence charts for multi-cylinder engines.

Experiments determining piston displacement.

Experiments determining horsepower ratings at specific speeds.

UNIT: THE AUTOMOBILE EMBODIES MANY PRINCIPLES OF MACHINES

TOPIC: WHAT ARE THE PARTS OF THE FUEL SYSTEM?

1. The fuel transfer pump

The principle of operation.
Volume capacity.
Pressure capacity.
Displacement.
Work requirements.

EXPERIMENTS:

(1) Design and build operating demonstrator using a cam, electric motor, and mount.

(2) Conduct tests for pump efficiency and calculate actual efficiency vs. manufacturing specifications.

2. The Carburetor - - Operating principles and laws.

EXPERIMENTS:

(1) Engine tests for: Mixture and power output
Gas Consumption per mile.
(2) Calculations for fuel-air ratio.

(3) Operation of engine without venturi; incorrect venturi; correct venturi.

(4) High-speed jet orifice diameter: too small, too large, damaged.

UNIT: AUTOMOBILES EMBODY MANY PRINCIPLES OF MACHINES

TOPIC: HOW ARE CONDUCTION, CONVECTION, AND RADIATION PUT TO WORK IN YOUR AUTOMOBILE?

1. Liquid Cooled Engines - - Complete analysis and report of cooling system on late model car.

e.g. (1) Rate capacity of heat transfer from cylinder block to water.

(2) Rate capacity of heat transfer from water to air through radiator

(3) Rate capacity of fan.

(4) Rate capacity of pump.

EXPERIMENTS:

(1) Effect of additives to cooling water. (e.g) Change in boiling and freezing points with anti-freeze added.

(2) Determine thermal loss.

(3) Effect on pressure cap on efficiency of system.

(4) Determine range of thermostat valve.

(5) Determine H.P. requirement to operate cooling system.

(6) Analyze and describe temperature recording instrument. What makes the needle move?

2. Air Cooled Engines

Design features allowing for conduction.

Design features allowing for convection.

Design features allowing for radiation.

Thermal efficiency problems of air-cooled engines.

UNIT: THE AUTOMOBILE EMBODIES MANY PRINCIPLES OF MACHINES

TOPIC: WHAT SIMPLE MACHINES ARE FOUND IN AN AUTOMOBILE?

1. Levers
   - Pedals: advantage of
   - Handbrake: advantage of
   - Shift rod: advantage of
   - Steering mechanism: advantage of
   - Crankshaft: advantage of

2. Wheel and Axle

   Rear axle and wheels: Geometric problems of traction.
   Problems of tortion.
   Problems of differential.

   Front wheel system: Geometric problems of steering.
   Geometric problems of alignment.
   Geometric problems of balance.
   Geometric problems of suspension.

   Steering wheel: Compute M.A. of the combined simple machines that make up the steering mechanism.
   Analyze several types of steering systems.

3. Pulley
   - Problems of pulley ratios.
   - Problems of power transmission.
   - Problems of velocities.
   - Problems of M.A.

4. Screw
   - Problems of Torque - adjustment - pitch requirements.

5. Inclined Plane
   - Seat adjustment system.
   - Caster setting (front axle, solid type).

UNIT: THE AUTOMOBILE EMBODIES MANY PRINCIPLES OF MACHINES

TOPIC: HOW DOES THE TRANSMISSION SYSTEM OPERATE?

1. The Clutch

Friction Type: Forces involved.
Hooke's law employed.
Levers employed.
Heat problems solved.

Fluid type: Dynamics involved.
Laws of fluid mechanics.
Calculating efficiency.

2. The transmission gears

Dynamics of gears.
Ratio problems.
Transmission of power.
Design of gears.
Lubrication of gears.
Speed selection system.
Synchro-mesh system.
Velocity problems.

UNIT: AUTOMOBILES EMBODY MANY PRINCIPLES OF MACHINES

TOPIC: CRITERION INSTRUMENT --- EXERCISES

1. If the right front wheel of a car drops into a hole in the roadway, a moment of force is developed in the frame. Which way does this tend to bend the frame?

2. Demonstrate and describe three cases of useful friction in an automobile.

3. Why does a loaded car give a smoother ride than an empty one? Demonstrate and report.

4. Why is the proper adjustment of shock absorbers important? Demonstrate and report.

5. In operating a car, when is friction of the gears an asset?

6. Explain the operating principles of a four cylinder, four-stroke cycle gasoline engine. Use graphs and charts and explain how the physical laws apply.

7. What factors cause a V-8 to run smoother than a 4 cylinder engine? Demonstrate by charts. Also, set up a comparison test.

8. In what way does the Venturi tube affect the gas consumption?

9. Why is cold-weather starting a problem? Give reasons for cold starting difficulties.

10. What is vapor-lock? Explain the physical phenomena responsible for the condition.

11. Describe in detail the M.A. of a foot brake pedal. Determine the wheel-cylinder pressure attainable by yourself as operator of the vehicle.

12. In designing a steering wheel, what problems might result from too large a wheel?

13. Are the pulleys used in an auto "fixed" or "movable?" Explain.

14. What is the principle advantage of a worm gear for driving the rear wheels?

UNIT: MECHANICS

INTRODUCTION:

The dominant objective of this unit is to assist the learner to relate his knowledge of simple machines which he learned from a previous set of experiences, to the significant elements with which the mechanical engineering technician works.

In this unit we borrow heavily for rational from the Physical Science Study Committee materials, and approach the study of mechanisms through kinematic exploration to be carried on both in the physics class and in the Tech Laboratory.

This unit will cover less topical material than usually presented in high school courses in favor of a more penetrating analysis of the physical and mathematical associations of machine elements.

UNIT OUTLINE:

1. THE KINEMATICS OF PANTOGRAPH MECHANISMS.
2. THE DYNAMICS OF PANTOGRAPHS (Bar Mechanisms).
3. THE KINEMATICS OF CAMS AND FOLLOWERS (Types of motion).
4. THE DYNAMICS OF CAMS AND FOLLOWERS (Rates of Motion).
5. THE KINEMATICS OF GEARS.
6. THE DYNAMICS OF GEARS (Torque Converters).

UNIT: MECHANISMS

TOPIC: THE KINEMATICS OF PANTOGRAPH MECHANISMS

OBJECTIVES:

1. To gain experience in analyzing and describing the resultant motion in a linkage system, using models and plotting graphs.

2. Study and describe factors affecting the modification of motion patterns resulting from ratio changes between the elements of the mechanism.

3. To solve simple mechanical ratio problems mathematically using the equation:

$$\frac{\text{OUTPUT}}{\text{INPUT}} = \frac{f_h}{f_g}$$

NOTE: The elements of numerical trigonometry involving right angle functions may be introduced here.

4. To design and construct a pantograph device for:

   (1) Drafting
   (2) Engraving
   (3) Transmitting motion

REFERENCES:

Blackwood, et al, HIGH SCHOOL PHYSICS, Rev. Ed., Chapter 3, Pages 35-43

Efron, Alexander, MECHANICS, Rider, 1958, Chapter 3, pages 37-52

JETS-O-GRAM, MACHINE ELEMENTS, Univ. of Michigan, Nov. 4, 1959, 36 pages.

UNIT: MECHANISMS

TOPIC: KINEMATICS OF PANTOGRAPH MECHANISMS

Test To Accompany Unit on Mechanisms

FACT #1 You know that a system of links arranged in a certain set of ways will make up a machine called a pantograph.

QUESTIONS:

1. A pantograph is an example of ____________________

   (a) a simple machine
   (b) a machine element
   (c) a linkage mechanism
   (d) a first-class lever

2. Which phrase best describes a pantograph?

   (a) It translates power in a straight line from the source to the work area.

   (b) It is composed only of straight-line elements.

   (c) When the point of input is moved, the point of output will move only in a straight line.

3. Mathematically a pantograph can be said to be:

   (a) an adding mechanism
   (b) a subtracting mechanism
   (c) a differential mechanism
   (d) a proportioning mechanism

FACT #2 A pantograph mechanism can be applied to other machines to enlarge or reduce motion. Most engraving machines have a pantograph motion interposed between the tool and the stylus.

QUESTIONS:

1. Study the diagram following, substitute your own values for the lettered dimensions and solve the accompanying equation.

(ALL DRAWINGS ARE TO BE MADE BY THE STUDENT FROM INFORMATION PRESENTED IN THE CLASSROOM OR TEXT).

$$F : L = f_h : f_g$$

OR $$\frac{F}{L} = \frac{f_h}{f_g}$$

Answer: ______________________________

QUESTIONS:

2. Using the equation you just solved, see if you can apply it to the following job situation:

You have an engraving problem requiring the reproduction of a complex pattern from a small die to a large-scale die in the ratio of 1.78 : 1. Using the pantograph mechanism arrangement given in the preceding problem, determine the lengths of the elements for setting up the machine.

UNIT: SOUND

TOPIC: LESS NOISE FROM SMALL ENGINES

LESSON: HOW A NOISE SURVEY IS MADE

OBJECTIVES:

(1) To put into practice the sound measurement techniques learned in the unit on measurement techniques important to technicians.

(2) To identify and classify engine noise according to engineering principles, e.g., aerodynamic noise or mechanical noise.

(3) To experiment with the three general principles applied to the problem of noise reduction, e.g., (a) eliminate the source, (b) isolate sound and vibration, (c) confine or absorb radiation.

(4) To do a report containing graphs, problem charts, and a technical explanation covering the problem and its solution.

FOUNDATION INFORMATION:

Everywhere one goes today he is likely to be only a short distance from some kind of internal combustion engine. Neighborhoods used to hum with gossip, now the putt-putt with power lawn mowers and motor scooters. Chain saws, golf carts, power generators, outboard motors and portable power pumps labor noisily everywhere - to the growing irritation of the noise-conscious public.

Legislative action has resulted from the increased noise and engine designers are faced with the task of developing and perfecting noise control devices that will allow the small engines to meet tougher zoning restrictions. The test procedures used are fairly well standardized: by-pass each noise contributor to the engine in succession and make a "noise spectrum analysis" after each elimination as shown in the sample table and chart included with this lesson. Then make a shake test, in which the engine and its components are excited externally to find mechanical resonances and critical speeds.

Engine noise can either be classified as aerodynamic or mechanical noise. Exhaust, intake and blower account for the aerodynamic noises. Mechanical noise comes from vibrating structural members, valves, gears, cams, and the ignition system.

Three general principles apply in noise reduction: Eliminate the source; isolate sound and vibration; and confine or absorb radiation.

Eliminating the source is ideal, but if not possible or practical, then sound isolation should be used.

Sound absorption is used only when other methods are impractical.

It is better to stop noise than to isolate or absorb it later!

UNIT: SOUND

TOPIC: LESS NOISE FROM SMALL ENGINES

LESSON: HOW A NOISE SURVEY IS MADE

Exhaust Noises

Sudden release of high-pressure engine exhaust gas into the atmosphere is the dominant noise-maker. The cource cannot be eliminated or isolated. This source must be confined or absorbed in mufflers. But attempts to reduce engine exhaust noise below other engine noise sources will result in higher back-pressure and larger muffler without contributing to over-all engine noise suppression.

Effective mufflers can be designed using the analogy of an electrical low-pass filter. These filters pass frequencies below a given level called the cut-off frequency, and reject frequencies higher than desired. Cut-off frequency for any engine muffler is determined from analogous equations for the equivalent electrical circuit. Reduction of noise attenuation A, at a frequency f above the cut-off frequency is:

$$A = 17\ m\ \ln \left(\frac{2_f}{f_e} \right)$$

Where m is the number of muffler chambers.

Single-chamber mufflers are usually not adequate for reduction of high-frequency noise. Therefore, two-chamber mufflers are sufficient except where extreme silencing is required. The two-chamber types are simpler to build and less expensive than mufflers with three or more chambers. Total muffler volume is seldom less than ten to twelve times engine displacement.

An initial-expansion chamber between exhaust ports and silencer will further improve noise reduction. Chamber volume V is:

$$V = 14,660\ S/f_a$$

where S is valve area in square inches and f_a is fundamental engine-exhaust frequency.

Absorption Silencers

Sound absorbing material (usually glass fiber or asbestos) around a perforated channel makes an effective absorption silencer, particularly in the

the range above 2000 or 3000 cycles, where noise is the most objectionable. Effectiveness relies mainly upon thickness and length of absorbant wall. Thickness should exceed one quarter the wavelength of the sound. Additional length beyond a minimum value contributes little because attenuation is exponential. However, effectiveness is lost when the perforated channel becomes clogged by exhaust particles.

Back-pressure is critical in two-cycle engines because incomplete scavenging causes unnecessary power loss. The mean static pressure at rated speed and load should not exceed six inches of water for small 2-cycle engines, and ten in. of water for 4-cycle engines.

For 2-cycle engines, with their usual gas-oil mixture which tends to deposit carbon on exhaust ports and muffler, provision should be made for periodic cleaning. Mufflers are preferable mounted vertically with the exhaust directed downward. This permits proper drainage of carbon, residue, and condensation.

Air implosions into the cylinder or crankcase are responsible for intake noise. Pressures at the intake are considerably lower than at the exhaust, so noise frequencies are usually lower.

Noise reduction here is similar to exhaust silencing. Acoustic and absorption filters work equally well as intake noise silencers, and the same fundamentals apply. The initial-expansion chamber is necessary because of low pressures.

Two problems arise in designing an intake silencer that do not exist for exhaust. The engine requires an air filter. This may help reduce intake noise if properly designed, using filter cloth or paper materials.

Pressure loss across an air cleaner-silencer is the other problem. It is much more critical on the intake side than on the exhaust side because it results in a much greater power loss for a given pressure loss across the silencer. Pressure loss for an intake silencer-filter should not exceed 3 in. of water.

Structural Vibration

Sound radiated from structural vibration comes from the cylinder head, cylinder block, crankcase housing, flywheel, gas tank, fan shrouds, baffles, and any other external engine components.

Intensity of the sound depends on:

(1) the applied force causing vibration
(2) the mechanical impedance of the vibrating member
(3) the radiation impedance of the vibrating member.

Amplitude of vibration is directly proportional to applied force and inversely proportional to mechanical impedance. Mechanical impedance is a function of the mass of the body, its stiffness and damping. At extremely low frequencies, mechanical impedance can be controlled by increasing stiffness.

Resonant frequency of a body is also dependent upon mechanical impedance and can be made to differ from the forcing frequency by adjusting damping, mass, or stiffness. Changes in damping, however, shift resonant frequency only slightly.

Efficiency of sound transmittion in the air is a function of radiation impedance. Reducing area of a vibrating surface causes increase in radiation impedance and a corresponding reduction in noise from the engine. To reduce coupling between the air and vibrating surface, dimension of the part should be less than one-quarter wavelength of the sound in the air.

Noise caused by structural vibration can be reduced these ways:

(1) Eliminate or reduce the exciting source.
(2) Use material with high damping qualities; for example, cast iron. Undercoat with sound-deadening material feasible.
(3) Increase stiffness by adding material. Use ribs or laminated construction where possible.
(4) Reduce area of radiating surface.
(5) Use vibration isolation devices liberally to de-couple structural members from the source of vibration.

The trend today is toward lightweight, high-speed engines, which precludes extensive use of more dense materials and "beefed-up" construction. Therefore, methods 1, 4, and 5 offer the most practical solutions.

Combustion pressures and unbalanced rotating surfaces inherent in small reciprocating engines are prime sources of vibration. Improved balance of rotating elements can reduce bearing wear and give smoother operation. Isolation in this case may no longer be necessary. Proper carburetion and ignition timing contribute to better combustion, resulting in smoother operation and reduced vibration. A cast iron flywheel can also aid in sound-deadening as well as reduced speed fluctuations.

Manufacturing clearances should be held to a minimum consistant with good design practice. Although this is a minor consideration, it can contribute greatly toward reducing "slap" and impace during stress reversals.

Valve-Train Noise

The 4-cycle gasoline engine with its poppet valves, camshaft, tappets and gears is an ideal breeder of noise. Valve impact, valve bounce, cam-drive gear impact, and tappet impact are the prime contributors to internal noise.

Zero-lash valve tappets offer no advantage over a well designed and well adjusted adjusted mechanical tappet. Similarly, stronger valve springs may prevent valve bounce, but can also create larger driving forces against the cam profile during the closing period. A reversed torque is then applied to the camshaft with resulting impact on the cam-drive gears. Repeated shocks transmitted this way through the camshaft and crankshaft radiate from external surfaces and are the worst sources of valve train noise. A quick-lift, high acceleration cam is particularly liable to this kind of noise.

Camshaft drive gears also cause resonant noise in the gear housing members. This predominates largely in only the 4 cycle engines, however.

Objectionable gear noise may result from non-uniform tooth loading, caused by fluctuating angular velocity and inertia in the rotating masses. Unbalanced elements, tortional vibrations, and reversals of torque are all contributing factors. In addition, inaccuracies in pitch and tooth profile may result in vibrations of various frequencies.

Confinement of Airborne Noise

As a last resort, or in many cases where extreme silencing is required, silencing hoods and enclosures may be used to decouple the engine from the air. Simply a partial enclosure or sound shield, lined with absorbant material, is sometimes sufficient to combat high-frequency noise and to direct sound away from low-noise areas.

Materials used in silencing hoods must be non-porous for efficient sound insulation. The extent of sound attenuation depends upon the weight per unit area of the material used; that is, for a given wall thickness, the most dense material is best. When light materials must be used, a double-walled hood is recommended, with walls carefully isolated from each other.

Sound absorbing lining (fiber glass, felt, etc.) inside the sound hood will absorbe a large part of the radiated acoustical energy. The hood, with its large surface area, can be a very efficient radiator if mechanically excited by the engine. Therefore, mechanical decoupling of the hood from the engine is imperative.

Minor Noise Sources

Cooling fan noise requires attention only in extreme silencing. Fan noise is made up of rotational noise and vortex noise - both approximately proportional to the sixth-power of the tip speed. The fundamental frequency is the product of the number of blades and the rotational speed. Harmonics are present, but those above the fourth can be neglected.

Pressure fluctuations in the crankcase of a 4-cycle engine contributes noise through the crankcase breather. This is not a serious design problem because pressure losses here are not critical.

Ignition noise is sufficiently low so that silencing is not necessary except under extreme conditions. Frequencies are in the higher octave bands and can easily be attenuated by enclosure or absorption. In many small engines, rubber-sealed weatherproofing encloses the ignition system, attenuating noise completely.

WORD LIST

Aerodynamic noise
Isolation
radiation
irritation
standardized
noise-conscious
excited-excitation
spectrum analysis
resonance
critical
vibrating
absorption
dominant
confined
mufflers
back-pressure
suppression
frequencies
attenuation
displacement
initial
fundamental
perforated
channel
implosions

acoustic
inverseley proportional
directly proportional
resonant
feasible
laminated
unbalanced
tortional
fluctuations
impact
angular
velocity
inertia
torque
silencing
non-porous
harmonics
decibals
impedance
knowcking
detonation
slapping
intermittent
sound-proofing
insulation

UNIT: MECHANICS

TOPIC: CONTROLLING TORTIONAL VIBRATIONS IN CRANKSHAFTS

LESSON: FOUNDATION INFORMATION ABOUT "DAMPERS AND SUPPRESSORS"

In multi-cylinder internal combustion engines which operate through a wide range of speed it is practically impossible to keep the range free from speeds at which severe crankshaft tortional vibrations will occur. However, since the resonant tortional vibrations of a crankshaft are governed by the conditions of resonances existing between the torque impulses and the natural frequencies of tortional vibration of the crankshaft system, it is sometimes possible to control these conditions to some extent by the design of the crankshaft. This can be easily performed, however, in engines that have only a narrow operating speed range. It is possible to flexibly and frictionally connect the flywheel to the crankshaft so that the system will have little response to the exciting forces at the resonant frequencies. Also, mechanical devices have been used for automatically changing the moment of inertia or the stiffness of the crankshaft at certain engine speeds in order to avoid resonance. Methods have also been developed in which the moment of inertia of the crankshaft is varied through the cycle of the engine revolution. Devices such as these, although they have merit, are not used widely, usually because they are too complex and too costly. The most common method of tortional vibration control is the use of a suppressor of some sort to eliminate the existing tortional vibrations.

The need for a tortional suppressor depends upon several factors. In passenger car design, vehicle vibration and noise are the deciding factors. In bus and truck engine design, crankshaft stress, timing gear wear, and camshaft operation may be the important factors. In motorship drives, crankshaft and propellor shaft stresses, auxilliary and main gear drives, wear and noise are the prime factors in determining the need for a suppressor. Each design of engine, together with the driven equipment, must be investigated separately in order to select the proper type of suppressor.

Tortional vibration suppressors are commonly described in one of four general clissifications:

(1) dampers
(2) tuners
(3) tuners of damping
(4) de-tuners

UNIT: VIBRATION

TOPIC: FOUNDATION INFORMATION - - About Dampers and Suppressors

LESSON: Controlling Tortional Vibration in Crankshafts

INTRODUCTION

DAMPERS INTRODUCE WORK ABSORBING FORCES INTO A SYSTEM. These forces are brought into operation when the crankshaft tortional vibration amplitude reaches a predetermined value. Basically, dampers consist of heavy flywheel rings mounted coaxially with the engine crankshaft and caused to rotate with it either through liquid or solid friction.

When the crankshaft speed of rotation is uniform, the shaft and the damper flywheel rotate as a unit. During crankshaft tortional vibration, the flywheel has the same oscillation only if the torque necessary to give the flywheel maximum acceleration is less than that causing the friction furfaces to slip. If the amplitude of vibration of the shaft, at the damper location, is caused by a greater torque than this, slip between the two surfaces occurs with consequent energy loss. Through correct design, the energy absorption by friction balances the harmonic torque input at any desired level of amplitude, thus limiting the vibration stresses at critical speeds to safe values.

Tuners operate by neutralizing primary torques - - Dampers operate by dissipating energy as it is passed into the crankshaft system by exciting harmonic torques. The same result can be obtained by adding another vibrating system to the main one which opposes the exciting torques with a vibratory torque. In this type of control there is no energy dissipation as occurs in dampers, but rather a neutralization of the torques which might lead to serious vibrations.

Tuners having no damping are limited in their application to constant speed range. Although critical speed of the original system is eliminated with the application of the tuner-damper, two new critical speeds arise. One is above the original and the other is below the original. Unless damping is introduced into the tuner, these new criticals often result in excessive amplitudes. Consequently, for wide speed range engines tuners incorporating dampers are a necessity.

These tuner-dampers consist of a flywheel mass connected through leaf springs, or rubber having hysteresis qualities. The action is the same as that in the tuners except that the energy causing the excessive tortional vibration at the two new critical speeds is dissipated by means of the inter-leaf friction or the rubber hysteresis, and amplitudes at these criticals are held to safe limits.

THE PRE-TECH LAB - De Anza High School

The purpose of the shop courses referred to in the Physics Section as a Tech Lab are three-fold:

1) To reinforce the instruction the student receives in physics and math.
2) To provide a laboratory in which the student does problem solving in research problems related to physics and mathematics.
3) To introduce tools, machines, and materials so that the student will understand the function of the shop areas in research and development work.

Students.will work on projects relating to the concepts in physics concurrently with the physics instruction. Projects may be individual or group projects, but each student working on a project will be responsible at all times for what he is doing and why he is doing it. It is important to emphasize that these projects are short in duration, in keeping with the course presentation in physics. Each student will be issued a clip board and sketch board. The clip board must be readily available while working on each project and it shall include the following information:

1) Statement of the problem (sample problem sheets follow in this report.
2) Sketches of the project and parts.
3) Clippings from magazines and other research dealing with the problem.
4) Math calculations relating to the problem.
5) A statement on methods of testing and results.

Students will be assigned such projects as their knowledge and skills with machines dictate. The students with little training in the use of tools and machines will receive training in the areas of wood, metal, and electricity.

Although given in the industrials arts areas, this course is primarily a lab for physics instruction with the added advantage of shop training and facilities. This course differs from the traditional shop program by requiring the student to fully understand the scientific theory behind each project rather than merely to develop hand skills. Further, the course content is such that it closely parallels the methods and procedures used in research and development in industry. The student realizing this approach should quickly develop a higher sense of status in his own mind as well as in the minds of others. The method of instruction is also such that the instructor plants more directed responsibility upon the student in that he must in a limited sense, perform the customary research and design of the project prior to its development. While the course outlines which follow are presented as a separate unit of instruction, it is presented in the same integrated manner as the program previously described at Harry Ells School.

PRE-TECH LAB - - Course Outline

UNIT # 1 Drafting Review:

Topic 1. The Shop Sketch
Topic 2. Freehand Sketching
Topic 3. Designing and Planning

UNIT # 2 Safety:

Topic 1. General Safety
Topic 2. Hand Tool Safety
Topic 3. Machine Tool Safety
Topic 4. Pain and Volatile Liquid Safety

UNIT # 3 Measurements: Physics Unit: Measurement Techniques Important To The Technician

Topic 1. Systems of Measurement
Topic 2. History of Measurement
Topic 3. Measurement tools
Topic 4. Measurement of Length and Surface
Topic 5. Measurement of Mass
Topic 6. Measurement of Weight
Topic 7. Measurement of Time
Topic 8. Electrical Measurement
Topic 9. Measurement of Pressure
Topic 10. Measurement of Temperature
Topic 11. Measurement of Fluid Flow
Topic 12. Calorimeters
Topic 13. Automatic Controls

UNIT # 4 Hand Tools: Physics Unit: Nature of Matter

Topic 1. Wood working Tools
Topic 2. Metal working Tools
Topic 3. Electric Tools.

UNIT # 5 Wood Working Machines: Physics Unit: Fundamentals of Machines

Topic 1. Safety Review
Topic 2. Classes of Machines
Topic 3. Table Saw
Topic 4. Planer and Jointer

Topic 5. Shaper
Topic 6. Band Saw and Jig Saw
Topic 7. Drill Press
Topic 8. Wood Lathe

UNIT # 6 Metal Working Machines: Physics Unit: Fundamentals of Machines

Topic 1. Safety Review
Topic 2. Classes of Machines
Topic 3. Metal Lathe
Topic 4. Milling Machine
Topic 5. Metal Shaper
Topic 6. Power Hack Saw
Topic 7. Drill Press
Topic 8. Grinder
Topic 9. Metal Band Saw
Topic 10. Metal Shears
Topic 11. Pan Brake
Topic 12. Bar Folder
Topic 13. Benders

UNIT # 7 Welding and Casting: Physics Unit: Machines use Heat Energy - Heat Produces Expansion

Topic 1. Arc Welding
Topic 2. Gas Welding
Topic 3. Spot Welding
Topic 4. Soldering
Topic 5. Casting
Topic 6. Expansion of Solids

UNIT # 8 Internal Combustion Engines and The Automobile: Physics Unit: The Automobile is an Example of many Principles of Machines.

Topic .1. The Frame
Topic 2. Springs and Shocks
Topic 3. Friction
Topic 4. Fuel System
Topic 5. Internal Combustion Engines

UNIT # 9 Projects Related to Mechanics: Physics unit: Mechanics

Topic 1. Heat engines and pressure
Topic 2. Gravity

Topic 3. Velocity
Topic 4. Projectiles
Topic 5. Center of mass
Topic 6. Center of gravity
Topic 7. Strength of materials
Topic 8. Conservation of energy and momentum
Topic 9. Circular motion
Topic 10. Angular Momentum
Topic 11. Periodic Motion

PRE-TECH PHYSICS - De Anza High School

UNIT: SCIENTIFIC MEASUREMENT AND TECHNICAL APPLICATIONS

TOPIC: THE MEASUREMENT OF THE LOCAL RATE OF ACCELERATION DUE TO GRAVITY

Objectives

1. To design and build a mechanical system around a simple pendulum with which to obtain the local rate of acceleration due to gravity in feet per sec^2 cm per sec^2 to the third decimal (1 x 10 - 3).

2. To write a technical description of the mechanical system including dimensions, obtainable data, and unique characteristics.

3. To learn how to operate and interpret a Beckman e-put counter for the measurement of time delay.

Lessons

Monday, November 5

HOW TO CONDUCT AN EXPERIMENT TO OBTAIN PROMPT AND ACCURATE DATA.

Tuesday, November 6

HOW TO ANALYZE EXPERIMENTAL DATA

Wednesday, November 7

HOW TO CONVERT RECORDED SOUND DATA INTO LINEAR TIME DATA WITH AN OSCILLOSCOPE.

Thursday, November 8

HOW TO MEASURE THE PERIOD OF A SIMPLE PENDULUM WITH AN e/PUT COUNTER

Friday, November 9

CONDUCT EXPERIMENTS WITH SENSITIVE PENDULUM SYSTEM AND DETERMINE THE LOCAL g-FACTOR.

HOW TO CONDUCT AN EXPERIMENT AND OBTAIN PROMPT AND ACCURATE DAT

Objectives

1. To provide an experience in the use of a Beckman electronic counter.

2. To learn to use electro-magnetic sound recording equipment to record test results.

3. To confront the learner with the problem of converting sound recorded data into units of time.

4. To pose to the learners the challenge of devising a method for converting and measuring the recorded sound data.

"SAMPLE PROBLEM SHEET"

TECH LAB: FORCE AND MOTION

The Problem: Design an aid to show force vectors and the resultant of two or more forces acting on each other.

The Limitations:

1. Size may be whatever is suitable but no larger than two feet square.
2. Materials may be anything that is readily available.
3. Time limit is two weeks including planning.
4. A shop sketch of the aid must be included as part of the final product.
5. A written report must be included as part of the final product.

The Presentation:

1. Each student will give a demonstration and explanation of his aid to the rest of the class. Time limit of ten minutes.

The Judging:

1. Each aid and demonstration will be judged to see if they clearly explain the following points.
    a) A vector gives both direction and magnitude.
    b) Vectors in a vector diagram originate from a point of application.
    c) The resultant of two forces acting in the same direction is the sum of the forces.
    d) The resultant of two forces acting in opposite directions is their difference.
    e) The resultant of forces acting at angles to each other may be found by the triangle of forces or parallelogram of forces method.
2. Each entry will be judged as to workmanship and use of materials.

"SAMPLE PROBLEM SHEET"

TECH LAB: BALANCE AND EQUILIBRIUM

The Problem: To design and construct a device to explain dynamic and static balance and equilibrium

The Limitations:

1. Size may be whatever is suitable but no larger than two feet square.
2. Material may be anything that is ready and available.
3. Time limit is two weeks including planning.
4. A shop sketch of the project must be included as part of the final product.
5. A written report must be included as part of the final product.

The Presentation:

1. Each student will give a demonstration and explanation of his device to the rest of the class. Time limit ten minutes.

The Judging:

1. Each device and demonstration will be judged to see if they CLEARLY explain the following points:

   a) An object that is balanced while at rest is statically balanced.

   b) An object that is balanced while in motion is dynamically balanced.

   c) The center of gravity is the point at which an object is statically balanced.

   d) A part of mechanism is in stable equilibrium when the center of gravity falls within it's base.

   e) Unstable equilibrium results when the center of gravity falls outside the base.

2. Each entry will be judged as to workmanship and use of materials.

UNIT: DRAFTING

TOPIC: THE SHOP SKETCH

PROJECT: Miscellaneous Drawing Problems

ITEMS:

1. Use of cross-section paper
2. Use of isometric cross-section paper
3. Determining the scale
4. Dimensions and notes
5. Placement of views

UNIT: MEASUREMENT

TOPIC: Pressure Measurement

PROJECT:

1. Vacuum gauges
    a) How are they used in automotive testing?
2. Engine indicators
    a) Attaching to engines
    b) How to read indicators and why they are used
3. Strain gauge
    a) REF: MECHANICAL ENGINEERING 9-47, pp 774
       MECHANICAL ENGINEERING 3-43 pp 169-172
    b) To show expansion of pressure shells.

Example 1

UNIT: MEASUREMENT

TOPIC: Pressure

PROJECT:

1. Diaphragm gauge
    a) Study diaphragm gauges as used for welding and spray painting
    b) Prepare a cutaway model of a diaphragm gauge. Cut away a section of the outside shell to show operation.

Example 2

UNIT: MEASUREMENT

TOPIC: Temperature

PROJECT:

1. USE OF PYROMETER
    a) How to read dial of pyrometer
    b) Why we need to know the heat of molten metals

Example 3

UNIT: WELDING AND CASTING

TOPIC: Expansion of solids

PROJECT:

1. Rivets
    a) Hot rivets, use of rivets, size of hole, use of rivet set
    b) Gold rivets

2. Shrinking of metals
    a) Use of shrink rules
    b) Rate of expansion in different metals

3. Pattern making
    a) Reasons for double-shrink
    b) Draft and its purpose

Example 1

UNIT: INTERNAL COMBUSTION ENGINES AND THE AUTOMOBILE

TOPIC: Shocks and Springs

PROJECT:

1. Set up a test project to test the compression of automobile springs.
    a) Use a valve spring tester, and test a random sample of valve springs and record differences.

    b) Prepare a cutaway of an automobile shock absorber and prepare a report as to the physics involved in its operation

Example 2

UNIT: INTERNAL COMBUSTION ENGINES AND THE AUTOMOBILE

TOPIC: How Friction is Used.

PROJECT:

Clutch, tires, brake.

1. Design and build a model or cutaway of an automobile clutch.
2. Design and build a working model of the brake shoe and drum of an automobile.
3. Design and build a model to show the use of friction of automobile tires.

Example 3

UNIT: INTERNAL COMBUSTION ENGINES AND THE AUTOMOBILE

TOPIC: How are molecular forces of gases utilized?

PROJECT:

1. Internal combustion engines.
   Study the action of a gas engine using cutaway models.
2. Study the action of air compressors using both diaphragm and piston models.
3. Bernoulli's principle and how it is ued in:
   - a) Carburetors
   - b) Aspirators
   - c) Paintsprayers
   - d) Sand blasters
   - e) Venturi tubes

Example 4

UNIT: INTERNAL COMBUSTION ENGINES AND THE AUTOMOBILE

TOPIC: Internal combustion engine

PROJECT:

1. Construct a cutaway model of a gas engine.
   - a) Use to show cycles and principles of operation

Example 5

TECH-LAB UNIT: Measurement

TOPIC: Measuring the Quality called Length

Description of Project:

Sets of Metal (Aluminum, Brass, Steel) Discs of uniform size.

A set will consist of 10 discs each of the following sizes:

3 inches	in Dia.	3/4 of an inch thick
3 inches	in Dia.	1/2 of an inch thick
2-1/2 "	in Dia.	1/2 of an inch thick
2 inches	in Dia.	1/2 of an inch thick
1-1/2 "	in Dia.	1/2 of an inch thick
1 inch	in Dia.	1/2 of an inch thick
3/4 "	in Dia.	1/2 of an inch thick
1/2 "	in Dia.	1/2 of an inch thick

Each Disc will be to a tolerance of ± .010 of an inch.

EXAMPLE 1

PHYSICS UNIT: Measurement

NAME OF PROJECT: Uniform Discs

Procedure:

1. Students issued stock.
2. Students to set up stock in lathe and turn to a uniform specified diameter.
3. Students to set up cut-off tool and cut stock to a uniform thickness.
4. All Discs are to be held to a tolerance of ± .010 of an inch.

PRE-TECH LAB - - Project Outline

TECH-LAB UNIT: Measurement

PHYSICS UNIT: Measurement

TOPIC: Time Measurement

NAME OF PROJECT: Simple Pendula

Description of Project:

A cylinder of metal (steel or aluminum) suspended by a metal rod from a pivot so that it is free to swing.

EXAMPLE 2

Procedure:

1. Turn a piece of stock on the lathe to 1" in dia. and 2" long.
2. Drill and tap for 1/8" N.F.
3. Cut 1/8" N.F. thread on welding rod 2 ft. long.
4. Form a small loop on the opposite end of the welding rod.
5. Build a tripod stand of wood 30 inches high.
6. Use a piece of piano wire through the loop to act as a pivot

PRE-TECH LAB - - Project Outline

TECH-LAB UNIT: Measurement	PHYSICS UNIT: Measurement
TOPIC: Mass Measurement	NAME OF PROJECT: Equal Arm Balance

Description of Project.

A balance arm with a center pivot, and zero scale with a pan or tray suspended by chain from end to be used to balance unknown weights against known weights.

EXAMPLE 3

Procedure:

1. Construct an arm of wood or metal 12 inches long.
2. Drill a center hold 1/8" in dia.
3. Drill a small hole in each end 1/2" in from the end.
4. Construct a stand with a U shaped bracket on the top upright.
5. Mount the arm with a 1/8" steel pin.
6. Spin two pans 3" in dia. and 1/4! deep.
7. Drill 4 holes 1/4" in from the edge and fasten chain from pans to end of arm.
8. Balance and set zero scale

PRE-TECH LAB - - Project Outline

TECH-LAB UNIT: Measurement

TOPIC: Pressure

Description of Project:

A tall reservoir, equipped with an overflow tube to give constant head. Water may flow from any one of several horizontal orifices equally spaced above the table.

EXAMPLE 4

PHYSICS UNIT: Measurement

NAME OF PROJECT: Water Parabolas

Procedure:

1. Construct a sheet metal tank 8" in diameter and 26" high.

2. Equally space 6 orifices with shut-off valves along the tank.

3. At the 24" level leave an open tube to serve as an overflow

PRE-TECH LAB - - PROJECT OUTLINE

TECH-LAB UNIT: Heat engines and Pressure

PHYSICS UNIT: Machines

TOPIC: Heat Engines

NAME OF PROJECT: Hero's engine

Description of Project:

A small can with close fitting cover with two "L" shaped copper tubes soldered into the sides. Mount between a top and bottom pivot point and on a stand.

EXAMPLE 5

Procedure:

1. Solder copper tubes into opposite sides of can.

2. Construct a pipe stand with two arms perpendicular from the upright.

3. Solder a small washer in the middle of the top and bottom of the can.

4. A sharp pivot from each arm rests in the washer.

PRE-TECH LAB - - Project Outline

TECH-LAB UNIT: Projects related to Gravity

TOPIC: Gravity

PHYSICS UNIT: Mechanics

NAME OF PROJECT: Free fall of Steel Ball

Description of Project:

Two magnets connected in series; the upper one retains a steel ball while the lower retains an arm that carries a stylus in contact with a revolving drum.

EXAMPLE 6

Procedure:

1. Construct a pipe stand with an electromagnet adjustable to different heights.

2. At the bottom of the stand fasten an electromagnet attached to a stylus with a platform on one end.

3. A revolving drum driven with a phonograph motor is mounted on the base of the stand.

PRE-TECH LAB - - Project Outline

TECH-LAB UNIT: Project Related To Mechanics

TOPIC: Projectiles

Description of Project:

A tube about 2 feet long with a switch at one end. An electromagnet that holds a target connected so that the target drops when the switch is opened.

EXAMPLE 7

PHYSICS UNIT: Mechanics

NAME OF PROJECT: Monkey and Hunter

Procedure:

1. Attach two brass screws to an insulated end of an aluminum tube 24" long.

2. Wind magnet wire around an iron rod 1/2 " x 6 ".

3. Attach two fine copper wires across front end of tube.

4. Run wire from battery to electromagnet through switch

PRE-TECH LAB - - Project Outline

TECH-LAB UNIT: Projects Relating to Mechanics	PHYSICS UNIT: Mechanics
TOPIC: Center of Mass	NAME OF PROJECT: Rotating balls of different masses

Description of Project:

A rod with two balls of different masses, one at each end. A handle with a pin center that can be positioned along the rod.

EXAMPLE 8

Procedure:

1. Fasten two wood balls at each end of a dowel 18" long.
2. Drill 1/8" holes along the dowel between the two balls.
3. Turn a handle on the lathe and fix a 1/8" steel pin in the end.

PRE-TECH LAB - - Project Outline

TECH-LAB UNIT: Projects Relating To Mechanics	PHYSICS UNIT: Mechanics
TOPIC: Center of Gravity	NAME OF PROJECT: Center of Gravity

Description of Project:

A flat bar with slots milled along it's length. Several size discs with holes in the center that can be placed along the slots. A string run from both ends to the flat bar with a plumb line adjustable along the string.

EXAMPLE 9

Procedure:

1. Mill two slots 3/16" wide and 18" long - 3/4" x 40" piece of flat stock.

2. Cut several metal discs of different diameters and drill 3/16" hole in the center.

3. Drill an 1/8" hole in each end of the flat bar.

4. Run a string from one end of the bar to the other.

PRE-TECH LAB

UNIT: Projects Relating to Mechanics

TOPIC: Strength of Materials

PROJECT:

Devise apparatus for conducting:

1. Compression tests
2. Tensile Tests
3. Shear tests
4. Bending tests

EXAMPLE 10

PRE-TECH LAB - - PROJECT OUTLINE

TECH-LAB UNIT: Projects Related To Mechanics

PHYSICS UNIT: Mechanics

TOPIC: Circular Motion

NAME OF PROJECT: Chain Wheel

Description of Project:

A 6" loop of bicycle chain that will fit over a motor driven wood drum. Chain must be free to come off of drum.

EXAMPLE 11

Procedure:

1. Form a 6" loop of bicycle chain.

2. Turn a wood drum on lathe with a slight taper to the outside.

3. Attach plate to drum to fit shaft of motor.

PRE-TECH LAB - - Project Outline

TECH-LAB UNIT: Project Related To Mechanics	PHYSICS UNIT: Mechanics
TOPIC: Angular Momentum	NAME OF PROJECT: Gyroscope & Rotating Table

Description of Project:

A lead-loaded bicycle wheel with handles attached to the axle. A 24" diameter rotating table with solid base.

EXAMPLE 12

Procedure:

1. Tape lead around outside of wheel.

2. Drill and tape two pieces 3/4"x6" aluminum rod to fit axle.

3. Fasten lazy suzan bearing to one side of a 3/4 x 24" dia. plywood disc.

4. Build base of 2 x 4 and attach bearing and plywood disc.

PRE-TECH PHYSICS - - Harry Ells High School

Mr. Emmett O'Neill, Instructor of Physics at the Harry Ells High School in the Richmond City School System, makes the following statement in reference to Pre-Tech Science: ..... "Physics for technicians is a course of study designed for the average, capable, high school student. The content of this physics course is similar to the traditional curriculum as it is now being offered in the high schools. The most outstanding difference between the two curriculums is the team or multiple approach to the study of the science. This multiple approach in this area of study is made possible by the contributions of mathematics, tech lab, English, and drafting. These contributions from the different subject area fields focusing on one particular concept of the physics, present this curriculum in an integrated and cooperative fashion to the student. This type of presentation follows one of the theories of learning-reinforcement, and it obviously will be apparent to the student.

The distinguishing features of this course are the sequencing of material into small units of clarity, the time alloted, and the attention given to each concept under study. Physics as one element of this program has a distinct advantage over comparable physics courses in this time allotment sequence. For instance - the time alloted to the student is more than twice the normal time sequence offered in the traditional high school curriculum. The introduction of the course to the students is a unit covering some ten teaching days concentrating on the subject of measurement. This unit begins in the physics class, is enlarged in the Tech Lab, and is presented as literature in the English class.

"From this initial unit, the students will move through a study of:

a) force and friction
b) simple machines
c) pressure and liquids
d) force and motion
e) heat
f) sound and wave theory

This is the sequence of materials the students shall examine in the first year of this pre-tech program. Throughout the first year of this program the student is evaluated in terms of the objectives already prescribed as successful for completion of the course by the team of teachers. His progress and shortcomings are brought to the attention of the teachers (and more effort is spent in his direction). This is in keeping with another prescribed operational principle of insuring that all students shall be successful in this program. The sequence of materials and units of study for the second year of physics are composed of:

a) light
b) atomic energy
c) electricity
d) a one-semester survey of chemistry
   especially metallurgy

In the course outline for Harry Ells High School which follow, we have included, integrated within the physics program, the related shop work so that the reader may see how this type of work is integrated."

PRE-TECH LAB

UNIT: Measurement Problems

Instructions: The following measurement problems include the use of all of those measuring devices explained during the lecture and demonstration. Micrometer readings must be within .001" and scale measurements to the 1/64th". Students may start at any numbered problem, and then pass on to the next available item. Due to the fact that the student is graded competatively, all measuring devices must be un-set from the preceding reading or position and there will be no discussion during this period. This measurement problem is for your benefit.

All items are numbered 1 thru' 30.

#1. Piston - Determine length from skirt to dome using a scale. Ans.________

#2. Piston - Determine diameter using micrometer. Ans.________

#3. Piston - Determine diameter using micrometer. Ans.________

#4. Piston - Determine diameter using a micrometer Ans.________

#5. Cylinder - Cut hollow driveshaft stock 3" x________"
Include formula and calculations in space below.
Perform necessary lathe operations to bring to size and determine volumetric capacity.

#6. Sprocket - Record inside bore using calipers. Ans.________

#7. Helical gear - Record micrometer reading of bore. Ans.________

#8. Outboard engine cylinder - Record micrometer reading of bore.
Calculate volumetric capacity of cylinder. Ans.________
Use space below for calculation.

#9. Outboard lower unit - Record micrometer reading of side bore. Ans.________

PRE-TECH LAB - - Harry Ells High School - Statement of Purpose

The Tech Lab will function primarily as a reinforcing and motivating situation where students will construct test equipment and models to better express certain scientific functions. Shop skills will be taught incidentally to primary purpose.

The learning units in the Tech Lab will parallel in content the learning unit in the physics class. This will be accomplished by the use of a day-by-day planning chart on which is recorded the units being covered in science and English.

The laboratory will furnish the Tech-English with nomenclature for tools, machines and materials being used to meet the in-product of science and math understanding. Topics for reports pertinent to concepts, equipment, material and test results will be provided the students in order that they may learn to express themselves scientifically. These reports and nomenclatures will be part of their English requirements in conjunction with laboratory content.

In brief, this laboratory will be a program oriented to problem solving rather than a project centered program that is designed to develop shop skills. It will differ from the traditional shop program in that every effort will be made to integrate the course content with that of science, English and mathematics and drafting.

The examples of the shop projects were included in the physics outlines - see pages of previous outlines.

MEASUREMENT

"WHEN YOU CAN MEASURE WHAT YOU ARE SPEAKING ABOUT, AND EXPRESS IT IN NUMBERS, YOU KNOW SOMETHING ABOUT IT: BUT WHEN YOU CANNOT MEASURE IT, WHEN YOU CANNOT EXPRESS IT IN NUMBERS, YOUR KNOWLEDGE IS OF A MEAGER AND UNSATISFACTORY KIND: IT MAY BE THE BEGINNING OF KNOWLEDGE, BUT YOU HAVE SCARCELY, IN YOUR THOUGHTS, ADVANCED IT TO THE STAGE OF SCIENCE."

(William Thompson)
Lord Kelvin
1891

MEASUREMENT

ORIENTATION UNIT:

GENERAL OBJECTIVES:

1. The pupils will become aware that an understanding of science depends on our ability to measure precisely.
2. This unit shall attempt to stimulate the students' curiosity about scientific phenomena and induce a favorable attitude towards physics.
3. This unit will provide him with a large variety of measuring experience without exhausting any particular field of measurement.

BEHAVIORIAL OBJECTIVES:

1. The student will be able to list the following units of measurement:

MASS	Pound, Ounce, Ton, Gram, Kilogram, Milligram
TIME	Seconds, Hours, Days
LENGTH	Meter, Decimeter, Centimeter, Millimeter, Mile, Yar, Foot, Inch

2. The student will be able to translate and use the foregoing units in finding the areas, volumes, and cubic. The student will be able to function in either the metric or English systems. He will derive the units of measure and show the relationship between quarts, pints, gallons, barrels, liter fluid ounces and cubic centimeters.
3. The student will be able to find the volume of irregular solids. He shall be able to define impenetratebility. The students shall be asked to:
    - A. Measure the volume of irregular solids by means of water displacement into an overflow can.
    - B. Define density and use the equation $\frac{D-V}{M}$ in determining density of an object.
    - C. Give the approximate densities of the following materials: Water, Gasoline, Aluminum, Copper, Iron, Lead, Mercury
    - D. Reproduce the formulas and equation for finding specific gravity and successfully solve problems dealing with specific gravity.

UNIT ON MEASUREMENT

(Experimental Exercise) - THE SIMPLE PENDULUM:

1. The student will construct (or observe) a simple pendulum.

2. The action of the pendulum will be discussed with the functions and dependencies discussed.

3. The Pendulum shall consist of a standard weight or mass suspended by means of a string of negligible weight.

4. The objective of the class period (55 min.) experiment will be to determine the factors retarding the period of the pendulum.

1. With the pendulum in operation, the students shall use three weights recording the time required for ten (10) periods. (Vibrations)

2. The student shall then vary the length of the weight, at least three lengths and then record the data.

3. Included in the data table shall be the angle of incident for all readings.

4. A graphic description shall be constructed indicating that the vibrations are determined by the length and the function of gravity rather than the weight of the mass.

TABLE TO ACCOMPANY EXPERIMENT

	Length	Time	Period	(T) Mass	Angle θ
M-1					
M-2					
M-3					

TOPIC: MEASUREMENT

UNIT: LINEAR MEASUREMENT (Scales)

What the student should know	Measurements	Instructional Aids
1. Standardized basic units measurement: 1. English-Metric 2. ASA - Intern'l Std. Ass'n	1. Visual identification of linear measuring tools.	1. Feirer, pp 4-158
2. Linear Measuring Tools Depth gauge Squares 2' flexible rule circumference rule machinist scale tape combination set drill point gauge Verniers Hook rule	2. Assemble and dis-assemble double square and combination squares.	2. Olivo, pp 31-32 pp 41-42
3. Transfer of measurements to layout surface.	3. Reading Ludwig, pp.43-48	3. Catalogs Stanley #34 Starrett #27 Millers Falls #49 Lufkin #89-#14 Brown & Sharpe No.I & #36M
4. Be able to read fractions on scale.	4. Project	4. Giachino&Feirer Bench-Metal Practice and Precision Measuring.
		5. The Tools & Rules for Precision Measuring. Starrett Film

EXAMPLE # 1

TOPIC: MEASUREMENT

UNIT: INSIDE AND OUTSIDE MICROMETER CALIPERS

What the student should know	Measurements	Instructional Aids
1. Identify main parts by name: 1. Anvil 2. Spindle 3. Frame 4. Lock Nut 5. Hub 6. Sleeve or thimble 7. Ratchet Stop	1. Read: (Decimal - Equivalents) Ludwig: pp 61-62	Decimal Equivalents 1. Wall charts
2. Proper care, handling and storing.	2. Pass out decimal equivalent cards in class and identify various fractions & their decimal equivalents.	2. Individual cards
3. Proper adjustments	3. Test on converting fractions to decimals, add fractions to nearest division on scale. (Ludwig pg.61)	3. Micrometer Reading Made Easy, (Pamphlet) The Lufkin Rule Co.
4. How to take precision readings.	4. Read: (Micrometers) Ludwig: pg.63-69	4. How to Read, Use and Care for Micrometers and Vernier Gauges.
5. Decimal equivalents.	5. Take required measurements from pistons and crankshafts as required by instructor's record for correction.	5. Basic Bench Metal Practice and Precision Measuring, Giachino & Feirer
6. Make inter-changeable adjustments for diameters 2" to 6" on Starrett micrometer caliper #224-Set A.		6. Shop Theory, Henry Ford Trade School

EXAMPLE # 2

TOPIC: MEASUREMENT

UNIT: VOLUMES AND DENSITY

What the student should know	Assignments	Instructional Aids
1. Formula for determing volumetric capacities using metric & English systems.	1. Construction of various assigned cylinder capacities using: a. Sheet metal constructed cylinders. b. Completion of assignment sheet	1. Instructor demonstration 2. Olivo: pp 43-44
2. Determinations, mathematically of various densities as they apply to certain volumes: a. aluminum b. steel c. brass		
3. Determination of volumes as they exist in practical applications in the lab.		
4. Incidental learning. a. Facing on the metal lathe. b. Use of file and emery cloth - possibly wire buffing. c. Layout - using marking dye, surface plate and surface gauge.		

EXAMPLE # 3

TOPIC: **MEASUREMENT**

UNIT: LAYOUT

What the student should know	Assignments	Instructional Aids
1. Application of: a. surface plate b. angle plate c. surface gauge d. V-blocks	1. Reading: Ludwig: pp 49-59	1. Instructor demonstration.
2. Types and application of surface coloring.	2. Complete layout of a single hole punch. No matching required at this time.	2. Visual aids in the form of a completed assignment
3. Application of: a. Prick punch b. Center punch c. Dividers d. Hermaphrodite calipers	3. Layout of round stock using center head.	
	4. Scribe parallel lines using the hermaphrodite calipers.	
	5. Finding center of round stock using hermaphrodite calipers.	

EXAMPLE # 4

TOPIC: MEASUREMENT

UNIT: REFERENCES

1. KELLY, BLACKWOOD, HERRON	HIGH SCHOOL PHYSICS
2. BASIC SCIENCE	OLIVO pgs. 66-75
3. DULL METCALF	MODERN PHYSICS Pgs. 13-19
4. H. SEMAT	PHYSICS IN THE MODERN WORLD Pgs. 38-40

UNIT ON FORCE AND FRICTION

OBJECTIVES:

1. The student shall be required to define force (a LA Kelly) and give some basic illustrations of force from the elementary to the present day fields of force.

2. The student shall be required to precisely identify the units of force and be able to demonstrate the ability to manipulate these units.

3. The student shall become aware of the differences between Weight and Mass as they relate to the forces of friction.

4. The student shall demonstrate an understanding of friction either orally or in the solution of some practical and basic problems.

5. The student shall be able to describe the factors of force and friction as they function on various areas, loads and velocities.

6. The student shall possess the ability to describe friction as a valuable aid in our everyday uses and as a retarding force.

7. The student will be required to indicate how friction may be reduced and overcome in mechanical and practical senses.

8. The student will be required to define the differences between sliding and rolling friction.

REFERENCES:

BLACKWOOK, HERRON, KELLY - HIGH SCHOOL PHYSICS, Pgs. 8-17

H. SEMAT - - PHYSICS IN THE MODERN WORLD, Pgs. 47-55

E. SUTTON - DEMONSTRATION EXPERIMENTS IN PHYSICS, Pgs. 15-23 & 30-31

O. LUHR - - PHYSICS TELLS US WHY - Pg. 36

E. ROGERS - PHYSICS FOR THE INQUIRING MIND. Pgs. 105-124

UNIT ON FORCE AND FRICTION

1. The students shall perform experiments on inclined planes of different materials (a block, metal, toy car) and compute the coefficient of sliding friction. The experiment shall be performed a number of times with various materials and all data recorded.

2. The students shall construct an experiment with a toy car (M) being pulled across a smooth surface by a weight passing through an arrangement of pulleys.

3. The students shall complete the experiment described in their laboratory manual that accompanies their class text book which adequately explains center of gravity.

4. The experiment to illustrate the concept of horsepower shall be performed in tech lab.

UNIT OF MACHINES AND MECHANICS

GENERAL OBJECTIVES:

1. The student shall exhibit the ability to list and define the six basic machines orally and in writing.

2. The student shall possess the ability to describe verbally and mathematically the mechanical advantages of each machine.

3. The student shall have considerable drill increasing his ability to solve basic problems relevant to the six basic machines.

4. The student shall have the ability to recognize the loss of efficiency that will affect the ideal mechanical advantage, particularly the role of friction in reducing the mechanical advantage.

5. The student shall have the ability to recognize the basic machines and basic mechanics employed in familiar devices and other phenomena.

6. The student shall possess the knowledge and ability which shall enable him to construct a machine or combination of machines in the technical laboratory and demonstrate this project to the entire class.

7. The student shall be required to report on the observations of the practical applications of these machines and the mechanics and principles as they are used in industry.

The Lever: (General Objectives)

1. The student shall be able to recognize and identify the three classes of levers.

2. The student shall successfully express the mechanical advantage of the levers orally and in written equations and problems.

3. The student shall exhibit the ability to recognize the lever principles as they exist functionally in familiar objects and in machinery.

4. The student be required to construct, produce an oral report, and a demonstration to the class of equipment composed of a lever or combination of levers emphasizing the principles involved.

The Pulley: (General Objectives)

1. The student shall be able to recognize and describe the classes of pulleys and the combinations of the classes of pulleys.

2. The student shall be required to use successfully the equations for computing the mechanical advantage of any given pulley combination.

3. The student shall exhibit the ability to rig fixed and moveable pulleys and produce a given mechanical advantage.

4. The student shall demonstrate the knowledge and the relationship between a pulley rig and its corresponding lever class.

Wheel and Axle: (General Objectives)

1. The student shall have the ability to recognize the mechanical advantage of the wheel and axle as the ratio of the wheel circumference to the axle circumference.

2. The student shall demonstrate the ability to use the appropriate ratio in solving for the mechanical advantage of the wheel and axle.

3. The student shall possess the knowledge necessary in recognizing the wheel and axle principles in familiar apparatus.

4. The student shall demonstrate in writing and report the lever principles superimposed on the wheel and axle.

Inclined Plane and Wedge: (General Objectives)

1. The student shall be required to describe in class and a report the mechanical advantage of the inclined plane relative to the two primary planes of force.

2. The student shall demonstrate the ability in solving basic problems determining the mechanical advantage of the inclined plane and the wedge by the use of the two formulas required.

The Screw: (General Objectives)

1. The student shall possess the ability to describe orally and in writing the mechanical advantage of screw relative to the inclined plane and the wedge.

2. The student shall demonstrate the use of the formula and in addition, demonstrate the ability to realize the loss of efficiency due to friction and other factors.

3. The student shall be required to recognize the principles of the screw in familiar object and machinery.

Gears: (General Objectives)

1. The student shall demonstrate the ability in writing and orally the major purposes of gears, gear trains, and pairs of gears.

2. The student shall be able to apply the principles of simple machines to the applications of gears and their functions.

3. The student shall be required to perform a demonstration in class on the compound gear trains and the use of gear reductions.

4. The student shall be required to solve, in writing or mathematically, the advantages of gears - their efficiency - and their uses.

5. The student shall become familiar with and be prepared to explain the relation between couples, compound machines, the worm and worm gear and finally, a transmission.

General Objectives:

1. The student will be required to explain orally or in writing the law of machines as it relates to the simple and compound elements discussed.

2. The student shall be able to define and spell, as well as use in a technological report:

   Malleability, Toughness, Ductility, Elasticity, Fusibility, Vicosity, Colatile, Conductivity, Cohesion, Adhesion, Surface Tension, Emulsions

MACHINES AND MECHANICS

REFERENCES

BLACKWOOD, KELLY HERRON - - High School Physics, pgs 20-58

H. SEMAT - - Physics in the Modern World, pgs. 65-77

R. SUTTON - - Demonstration Experiments in Physics, pgs. 29-32

E. ROGERS - - Physics for the Inquiring Mind, pgs. 73, 426, 432

TOPIC: MACHINES

UNIT: WEDGE STUDIES

What the student should know	Assignments	Instructional aids
1. Hand hacksaw a) Types of blades (Number of teeth per inch) b) Set in saw blades c) How to mount blade in frame. d) Proper speed of cut, stance. e) Blade alloy & cost; how to order & source of supply. f) Demonstration of hand hacksawing.	1. Read: Hacksawing Ludwig - pp 73-77	1. Instructor Demonstration.
2. Cold Chisel a) Type & uses viewed and demonstrated. b) Grinding of: class demonstration c) Type of steel used. Spark test. d) Demonstration: to split a nut to shear sheet metal to remove a rivet	2. Read: Chisels & Chipping Ludwig pp. 83 to 87	2. Kelly; pp 45-47 Feirer: pp 61 Burghardt pp 114-20
	3. Random student participation as directed by instructor	

EXAMPLE # 1

TOPIC: MACHINES

UNIT: WEDGE STUDIES - continued

What the student should know	Assignments	Instructional Aids
3. Filing a) Shapes, sizes and cuts b) How mfg., how to order and where c) Types of handles d) Filing position & stroke e) Parts of a file f) Cleaning a file g) Principle of the wedge as it is applied to the function of the file	1. Read: Filing - Ludwig pp 95 - 98 2. Nicholsen: File Filosophy 3. Random Student participation as assigned by the instructor	1. Instr. demonstration on the use of the file. 2. Burghardt, pp 128-141 Feirer, pp 82-88
4. Test to include: a) Identification of types b) Spelling c) Usage d) All assigned reading material	4. Test covering wedge tools: a) Chisel b) File c) Hand Hacksaw	
5. Drills a) Cutting principle b) Three classifications c) Drill bit designs: shank design; flute design d) Nomenclature-spelling e) Grinding techniques f) Coolants g) Drill layout & drill shift correction h) Use of the tape & drill chart	1. Read: Ludwig: pp 163-172 pp 185-190 2. Review Test - Drills and drilling, and Tape & Drill Chart	1. Lecture & demonstrations.

TOPIC: MACHINES

UNIT: LEVERAGE STUDIES

What the student should know	Assignments	Instructional Aids
1. How leverage is applied by machines to perform work. a) Bar Folder b) Box & Pan Brake c) Tin Snips d) Drill Press e) Hoffield Bender f) Pliers g) Adjustable jaw wrench h) Industrial applications	1. Class construction problems: a) single hem b) double hem c) Fold & spot weld tin box as required by layout unit.	1. Class demonstration of various machines and their operations to show lever advantages.
2. Recognition of the three classes of leverage as applied to machines in the lab and elsewhere.	2. Lever problems as assigned.	2. Kelly; pp 36
3. Determination by experiments. a) Moments of Force b) Mechanical Advantages of lever systems c) Mechanical Advantages of speed of movement	3. Preparation of student reports progressing concurrently.	3. Ludwig pp.253 to 263
	4. Test to cover leverage materials to date.	4. Instructor demonstration: a) Bar folder b) Box & Pan Brake c) Tin snips d) Hemming with a tinner's setting hammer. e) Spot welding f) Olivo; pp.78 to 87

EXAMPLE # 2

TOPIC: **MACHINES**

UNIT: **INCLINED PLANE STUDIES**

What the student should know	Assignments	Instructional Aids
1. Inclined plane defined - direction of force.	Written: 1. Choose one example of the inclined plane used commercially or privately. Name of machine or address of location. a) Include: frequency of use, construction as to materials & design & pictures. b) Make a sketch determining one problem from the dimensions with the dimensions with the math solution. c) Use graph paper for sketch.	Olivo, pp 88 & 89 1. Instructor Demon. 2. Class Demonstration 3. Inclined plan demonstration & recording to be done by instructor as per reference text - Olivo pp 92 & 93
2. Mechanical Advantage of force. $MA_f \; \frac{\text{Resistance}}{\text{Effort}}$ or $MA_f = \frac{R}{E}$	2. Class assignment: Design and construct a pair of car lifts using the inclined plane principle. Lifts are not to move forward when car strikes leading edge of lifts.	
3. Mechanical Advantage of distance. $MA_d = \frac{RD}{ED}$	3. Design considerations: a) degree of incline b) type of material c) thickness-cost-aesthetics.	
4. Application of the inclined plane to a wedge.	4. Instructor to furnish adjustable inclined plan equipment, scales and graph paper.	
5. Identification of inclined plane applications: a) In the shop ⊆ tools b) On the campus c) Consumer d) Industrial		
6. (E) X (ED) = (R) X (RD)		

EXAMPLE # 3

TOPIC: SIMPLE MACHINES

UNIT: SCREW THREAD

What the student should know	Assignments	Instructional Aids
1. Screw thread uses and terms.	1. Homework assign.- How To Run a Lathe - pp 75 to 81	1. Burghardt, 4th Ed. 1953, pp 417-475
2. Transmition of motion with the screw thread. a) Lathe lead screw b) Vises c) Automatic machine feeds. Lathe, milling machine, shaper, surface grinder. d) Valves e) Circular saws	2. Instructor demonstration - cutting a thread, using the machine, lathe, tap and die equipment.	2. Kelly - pp.
3. Screw threads used in making adjustments & measurements: a) Calipers - Veniers b) Micrometers c) Elevating columns for raising & lowering tables	3. Instruction to each student on how to cut a practice thread: a) Lathe - instr. assig. b) Tap c) Die d) To include use of drill chart and actual drilling of hole prior to tapping.	3. Henry Ford Trade school School, Shop Theory, McGraw Hill pp 90-100
4. How screw threads are used as fastening & joining devices: a) Nat'l coarse b) Nat'l fine c) Self tapping screws d) Sheet metal screws e) Self locking screw devices f) Friction of Drill and Tap Chart. g) Function of the pipe thread h) Operation of taps & dies - how to adjust - how to choose the proper tap drill	4. Test to cover: a) Types of fastening devices b) Cutting threads on lathe c) Drill chart - taps and dies d) Screw thread nomenclature and applications of screws as pertains to adjusting devices, holding devices & power transmission methods.	4. South Bend Lathe Works, How To Run a Lathe, Vol. Ed.53 pp 69-86
		5. Olivo, pp 102-105

TOPIC: SIMPLE MACHINES

UNIT: SCREW THREAD - continued

What the student should know	Assignments	Instructional Aids
Accuracy of fit not important at this point.	5. Instructor demonstration using class constructed each stand.	
5. How force is transmitted by use of the screw thread (Physics applications) $\text{Pitch} = \frac{1}{\text{No. of threads per inch}}$	6. Class demonstration by instructor, Ref: Olivo pp 106, 107, 108 a) Develop a concept of screw threads b) Screw threads used to transmit motion c) Screw threads used to transmit forces.	
	7. Test assignment sheet, to be completed & turned in to instructor	
EXAMPLE # 4		

TOPIC: SIMPLE MACHINES

UNIT: LEVERS

What the student should know	Assignments	Instructional Aids
1. A lever is a rigid bar which turns around a fixed point called a fulcrum. 2. A lever diagram includes a simple line drawing of the type lever with known and required forces and distances identified. 3. A Class 1 lever has the fulcrum located between the effort and resistance forces. 4. A Class 2 lever has the fulcrum at one end and the effort force between the fulcrum and the effort force. 5. A Class 3 lever has the fulcrum at one end and the effort force between the fulcrum and the resistance force. 6. Regardless of the class of the lever, effort (E) X effort distance (ED) = resistance(R) X resistance distance (RD). 7. The mechanical advantage of force of a lever is the ratio of the resistance to the effort of force $MA_f = \frac{R}{E}$ 8. A lever is balanced when the sum of the moments of force tending to rotate the lever in one direction is equal to those forces tending to rotate them in the opposite direction.	1. Instructor demonstration and recording of experiment results of the three classes of levers. Ref: Olivo, pp83-86 - Experiments A, B & C a) Interpretations: Determining moments of force. b) Mathematical determination of the Mechanical Advantage of force. $MA_f = \frac{R}{E}$ of the three lever types. 2. Demonstration. Studies of lever machines as they apply to machines in the laboratory: a) Bar folder b) Box & Pan Brake c) Wrenches d) tin snips e) Cams f) Dake press g) Wood turn tools h) Hossfeld bender (bend cups for jack stand experiment, later.) 3. Class construction of a simple sheet metal box. a) Construction to include the use of several lever tools. b) Operation of the spot welder. c) Explanation of the kinds and functions of	1. Olivo, pp 78-87 2. Glenn, Harold T., Exploring Power Mechanics, 1962, pp 8-11 3. Class 2 Lever equipment to test compression of valve springs. 4. Beam or graduated lever weights and fulcrum. Olivo, pp 83 & 84

TOPIC: SIMPLE MACHINES

UNIT: LEVERS - (continued)

What the student should know	Assignments	Instructional aids
9. Nomenclature of machine and hand tools using one of the lever principles. 10. Recognition of the several types of sheet-metal. 11. Review of measuring methods for determining thickness of sheet metal. 12. Function and operation of spot welder.	(continued) various sheet metals 4. Class assignment - using auto valve spring tester (see plan sheet of 2nd Class lever). Assign each student a spring to check for compression resistance as specified for that make of engine. a) Record results on assignment sheet. Reference to further practical problems on levers to be included in this sheet. Olivo, pp. 86&87	

EXAMPLE # 5

TOPIC: MACHINES (Power) (Friction) (Lub.)

UNIT: PRINCIPLES OF MECHANICAL POWER MEASUREMENT

What the student should know	Assignments	Instructional Aids
1. Power is the rate of doing work. Power = Work ÷ Time $\text{H.P.} = \frac{\text{work (in foot pounds)}}{\text{33,000 X Time (In minutes.)}}$ 2. Positive power transmission is provided by using gears, linkage, and other mechanical devices or by direct drive. 3. Source of power must be brought as close as possible to point of drive in order to reduce frictional losses. 4. Friction is caused by: a) surface finish b) the cohesion and adhesion of molecules of the moving parts. c) weight of pressure 5. Common types of friction: a) starting b) rolling c) sliding 6. Coefficient of friction = $\frac{\text{Force (required to cause an object to slide)}}{\text{Weight (of object}}$ 7. Friction due to surface irregularities may be reduced by: a) precision machinery b) changing materials in parts that move c) using anti-friction bearings d) proper lubrication	1. Class Demonstration of measuring mechanical power with a Prony Brake (Olivo, pp 135) a) Student recording of this demonstration. Olivo, pp 125 2. Class demonstration of determining starting, sliding and rolling friction. Olivo, pp 136-137 a) Record info. individually as per above reference. Also complete the 3 Interpreting Result problems of friction coefficients. b) Turn in for a grade all demonstration recordings and coefficient problems. c) Student Testing. Olivo pp 138 Question #1 thru 8 3. Class Demonstration of effect of lubrication on starting and sliding friction. a) Prepare 3 tables for recording exactly as done for the preceeding experiment. b) Record results for grading. Complete quest. 2 & 3, Interpreting Results-Section, Olivo pg 137. c) Testing - Ques.1-8	1. Kelly, pp 11-19 2. Olivo, pp 128-140 3. Glenn, pp 25-28

EXAMPLE # 6

UNIT ON MACHINES AND MECHANICS (Experiments)

1. The students will construct lever from basic materials (meter stick and weights) indicating the differences between the classes of levers.

2. The students will construct a pulley, and sets of pulleys to lift various weights; computing the mechanical advantage of each.

3. The students shall complete their laboratory manual unit on the wheel and axle as presented by the author.

4. THE STUDENTS shall make use of the wedge and the inclined plane in class demonstrations while solving for the MA of these instruments.

5. The students shall construct a simple crane in class using simple equipment of the lab. The object being that of introducing equilibrium and components of force.

6. The screw and compound machines, for the most part, shall be constructed in the tech lab.

UNIT ON PRESSURE IN LIQUIDS (Objectives)

1. The student will be required to precisely indicate the differences between pressure and force.

2. The student will demonstrate the use of the formula "pressure - $\frac{\text{FORCE}}{\text{AREA}}$ " in solving practical problems of pressures in liquids and solids.

3. The student will demonstrate the ability to use metric units in solving problems related to the pressure in liquids and solids.

4. The student will be required to define and identify specific gravity and specific density while demonstrating the ability to compute the density of a particular object using $D = \frac{W}{V}$

5. The student will exhibit a thorough understanding of Pascal's law with its derivation while illustrating the principles of the power lifts, the power brakes, and steering of a modern automobile.

6. The student shall be able to relate the principle of Pascal to the theory of simple machines while employing the conservation of energy law to the devices of modern technology.

REFERENCES:

Blackwood, Herron Kelly -
HIGH SCHOOL PHYSICS, pgs. 60-76

E. SUTTON -
DEMONSTRATION EXPERIMENTS IN PHYSICS
pgss. 107-113

H. Semat - PHYSICS IN THE MODERN WORLD
pgs. 77-105

E. Rogers - PHYSICS FOR THE INQUIRING MIND
pgs 68-73 - 155-168

PRESSURE IN LIQUIDS (Experiments)

1. The students shall complete the unit in their laboratory manual which accompanies the text book that demonstrated Pascal's principle.

2. The students will have a class room demonstration using a small tube with several small holes in its sides. When filled with water and a pressure applied, streams of water will shoot out in all direction indicating the uniformity of pressure at all points.

3. The incompressibility of water shall be demonstrated by the classical method of a filled water bottle and putting pressure on the cork or sealer.

4. The students shall demonstrate the principle of hydraulics with the use of a water bottle, connected by a tube into which water is poured.

5. The STUDENTS shall complete the laboratory manual exercise that concern buoyancy.

6. The students shall demonstrate this principle of density in the standard manner.

7. The students shall be given a demonstration of the effect of atmospheric pressure on a gallon can alternately heated and cooled and then forced into a vacuum.

8. The projects for the construction of pumps shall be done in the tech. lab.

9. The students shall experience varying conditions which shall illustrate the differences between the mercurial and the aeroid barometer.

10. The students shall demonstrate the uses of a siphon pump and construct one of basic apparatus.

UNIT ON MOLECULAR ACTION (Objectives)

1. The student will trace the development of the molecular or atom theory as it is related to matter.

2. The student will investigate the several types of matter in terms of their atomic arrangement.

3. The student will be expected to describe the differences between gases, liquids, and solids, in terms of molecular cohesion.

4. The students will experience the derivation of the laws of attraction between molecules; i.e. Boyle's Law for gases is a beginning.

5. The student shall exhibit the ability to describe and identify elastomers and plastics in terms of their atomic patterns and illustrate some common examples of these materials.

6. The student will be able to define elasticity and to classify the various types of elasticity while giving examples of this feature.

7. The students shall become familiar with Hooke's Law: its experimental basis and derivation for the principle we know today.

8. The student shall become adept in the use of direct proportions for the solving of practical problems relating Hooke's Law.

9. The students shall become familiar with the limits of given substances and the physical properties allowing these limits. This includes a definition comparing alloys and pure metals.

10. The students shall be required to describe in writing or orally the function and operation of torsion suspension on modern automobiles, in terms of stretching or elasticity.

REFERENCES:

BLACKWOOD, KELLY, HERRON - HIGH SCHOOL PHYSICS, pgs. 110-119

H. SEMAT - PHYSICS IN THE MODERN WORLD, pg. 79 - pgs. 158-63

E. SUTOON - DEMONSTRATION EXPERIMENTS IN PHYSICS, pgs. 459-62

R. CARLETON - VITALIZED PHYSICS, pgs. 20-23

E. ROGERS - PHYSICS FOR THE INQUIRING MIND, Chapt. 35 & pgs. 649-54

MOLECULAR FORCES IN LIQUID (Objectives)

1. The students shall become familiar with the background of the Brownian Movement and the significance this experiment produced.

2. The students shall be able to define surface tension, describing some effects and performing some experiments to prove their conclusions.

3. The students shall explain the everyday used of this discovery and its future application. (i.e. Waterproofing)

4. The students shall become precisely familiar with what is termed capillarity action. A re-definition of adhesion and cohesion will be necessary for complete understanding.

5. The students will then be able to contrast the behavior of mercury molecules in terms of their activities in adhesion and cohesion.

REFERENCES:

BLACKWOOD, HERRON, KELLY - HIGH SCHOOL PHYSICS, pgs. 120-127

E. SUTTON - DEMONSTRATIONS EXPERIMENTS IN PHYSICS, pgs. 103-115

E. ROGERS - PHYSICS FOR THE INQUIRING MIND - Chapt. 6, pgs 87-104

UNIT ON FORCES ACTING TOGETHER (Objectives)

(Major aspects to be taught in Tech Math)

1. The student will demonstrate an understanding of the term "resultant" as it is used in Physics. This demonstration shall be in written or oral form.

2. The student will be required to find the resultant forces when all the forces move in the same or linear direction.

3. The student will be required to solve for the resultant force when the components are in opposition to one another.

4. The student will demonstrate the ability to define equilibrium in terms of the forces acting through and in opposition to each other.

5. The student will be asked to illustrate, through a variety of everyday activities and phenomenon, this sate of equilibrium.

6. The student will be required to define and use the parallelogram law in determining the resultant of two forces.

7. The student will demonstrate and define the meaning of components when two or more forces are substituted for one.

8. The student will be asked to illustrate forces acting together in a variety of activities experienced in everyday life.

REFERENCES:

BLACKWOOD, HERRON, KELLY - HIGH SCHOOL PHYSICS, pgs. 128-137

R. CARLETON - PHYSICS, pgs. 95-104

UNIT ON AERODYNAMICS (Objectives)

1. The students shall become familiar with the concept and experiment performed by Bernoulli and the principle that followed.

2. The student shall be able to describe some very common and often overlooked principles which have their birth from this concept.

3. The students shall then become familiar with some of the features of an airplane: defining such terms and functions as drag, stall, and fluid motion.

4. The students shall be able to explain the reasons for streamlining an object, some illustrations of this mode and common departures. (A/c, Hydrofoils, JETS)

5. The principles of flight shall become familiar with the students to the point when he may be able to thoroughly explain the development of an A/C.

6. The student will be required to demonstrate the major differences between the fluid friction (as in streamlining) and the friction which exists between two solids.

REFERENCES:

BLACKWOOD, HERRON, KELLY - HIGH SCHOOL PHYSICS, pgs. 138-147

H. ESEMAT - PHYSICS IN THE MODERN WORLD, pgs. 98-127

R. CARLETON - PHYSICS, pgs. 359-377

UNIT ON FORCE AND ACCELERATION (Objectives)

1. The student shall be required to define "inertia": use Newton's First Law as a basis, and solve some basic problems demonstrating this Law.

2. The student will solve, discuss, and describe the relation between inertia and acceleration.

3. The student will then define the function of Newton's Second Law and give some practical examples of this Law.

4. The student will be asked to demonstrate the relations of force, acceleration, and mass, as they are used in Newton's Second Law.

5. The student will then demonstrate Newton's Third Law of motion giving practical and everyday examples of this Law.

6. The student will be required to demonstrate the units of force and their derivation.

7. With the Laws down, the students will then demonstrate an understanding and "appreciation" of the experiments which led up to Newton's Laws of Gravitation.

8. The students will then be asked to present contemporary extensions of these Laws.

REFERENCES:

BLACKWOOD, HERRON, KELLY - HIGH SCHOOL PHYSICS, pgs. 171-191

H. SEMAT - PHYSICS IN THE MODERN WORLD, page 26

E. SUTTON - Demonstration Experiments in Physics, pgs. 46, 57-79

E. ROGERS - PHYSICS FOR THE INQUIRING MIND, pgs. 105-35

UNIT OF ENERGY AND MOMENTUM (Objectives)

1. The students will be able to discuss and define the differences between work and energy and contrast their capacities.

2. The students will then define Potential Energy: its derivation and solve some problems concerning potential energy.

3. The students will define kinetic energy: discuss the functions of kinetic energy, giving everyday examples and solving some problems.

4. The students will then be asked to define the differences between potential and kinetic energy: and the differences in the formation of their formulas.

5. The students shall be able to state the law of conservation of energy and illustrate the many application in familiar events.

6. The students will then be able to define momentum in relations to mass and velocity and the use of Newton's Second Law.

REFERENCES:

BLACKWOOD, HERRON, KELLY - HIGH SCHOOL PHYSICS, pgs. 208-225

E. SUTTON - DEMONSTRATION EXPERIMENT IN PHYSICS, pgs. 59-68

H. SEMAT - PHYSICS IN THE MODERN WORLD, pgs. 59-63

E. ROGERS - PHYSICS FOR THE INQUIRING MIND, Chapt. 26

UNIT ON MOLECULAR ACTION (Experiments)

1. The students shall complete the lessons in their laboratory manual as they are related to atomic theory, and the states of matter.

2. The students shall construct an apparatus with paine wire and various masses as an illustration of Hooke's Law while computing stress and strain and the elastic constant.

3. The students shall demonstrate the tensile strength of a chosen metal using the laboratory manual as their guide.

4. The students shall construct a balance table with two and then three masses while solving for the resultant forces.

5. The students shall demonstrate a toy car on an inclined plane with known masses and supported by an arrangement of pulleys and solve for the forces.

6. The students shall demonstrate the classic experiment of two objects descending in a vacuum and record the data necessary for conclusions.

7. The use of a toy car and a mass attached to a pulley to illustrate velocity. Data shall be recorded and conclusions reached.

8. The demonstrating of a gun and an object falling through space shall be illustrated in class.

9. The inclined plane shall be used by the students to calculate acceleration.

10. The students shall complete the unit in the laboratory manual that concerns accelerated motion and circular motion.

11. The students shall demonstrate the principle of air speed indicators and some speedometers as the effect of circular motion.

UNIT ON HEAT (Objectives)

1. The students will be able to cite the development of the head concept, using Rumford, Joules and those associated with this development.

2. The students will demonstrate an understanding of kinetic energy and how it is related to the heat concept.

3. The students will be able to describe and illustrate the difference which separate heat and temperature.

4. The students will be called upon to discuss the development of the thermometer from Galileo's crude model to the present series of theromometers.

5. The students will be able to distinguish between the Fahrenheit and Centigrade scales and quote the purposes of each.

6. The students will become familiar with and be able to demonstrate some everyday examples of the coefficient of expansion with a rational for this expansion.

7. The student will be able to define and illustrate:

Contraction
Expansion
Kinetic Energy
Thermostat
Thermometer
Heat
Coefficient of Expansion
Kelvin's scale
The Joule

REFERENCES:

BACKWOOD, KELLY, HERRON - HIGH SCHOOL PHYSICS, pgs. 228-245

H. SEMAT - PHYSICS IN THE MODERN WORLD, pgs. 141-148

E. SUTTON - DEMONSTRATION EXPERIMENTS IN PHYSICS, pgs. 230-243

E. ROGERS - PHYSICS FOR THE INQUIRING MIND, pg. 73, 387-393

UNIT ON THE MEASUREMENT OF HEAT (Objectives)

1. The students shall be able to relate the experiment of "Joule" on his honeymoon. .... in taking water temperatures at the top and bottom of a waterfall and the subsequent evolvement of the British Thermal Unit.

2. The student will demonstrate a thorough understanding of the law of conservation of energy: citing many illutsrations of this Law.

3. The student will be able to relate the causes of heat flow and their relation to changes in temperatures.

4. The students will be able to manipulate the units of heat measure, the calorie and the BTU and present rational for their development.

5. The students will be able to describe "specific Heat", its purposes and funtions.

6. The students will produce an experiment in class using the calorimeter in finding the specific heat of particular substances.

REFERENCES:

BLACKWOOD, HERRON, KELLY - HIGH SCHOOL PHYSICS, pgs. 268-279

E. SUTTON - DEMONSTRATION EXPERIMENTS, pg. 230-233

H. SEMAT - PHYSICS IN THE MODERN WORLD, pg. 146

E. ROGERS - PHYSICS FOR THE INQUIRING MIND, pg. 73

TOPIC: HEAT

UNIT: DETERMINING SPECIFIC HEAT

What student should know	Assignments	Instructional Aids
1. The heat required to raise the temperature of a body: $H = W X s X (t_2 - t_1)$ W - weight s - specific heat $(t_2 - t_1)$ temperature increase	1. Instructor demonstration determining specific heat. a) Students will record individual results on Assignment Sheet. Olivo, pg. 255-256. b) Students to individually complete, INTERPRETING RESULTS ---- (Olivo, pg. 256 & 257 - Assignment Sheet.	1. Olivo, pp 255-256 2. Kelly, pp 269-279
2. Recognition, operation, and construction of heat measuring instruments: a) Thermocouple b) Pyrometer c) Thermometer d) Calorimeter	2. Instructor to select test covering: a) Sources and nature of heat energy. b) Factors affecting heat. c) Construction of thermometer: Construction of pyrometer: Construction of thermocouple d) Heat range colors	

TOPIC: HEAT

UNIT: MAKING A THERMOCOUPLE

What the student should know	Assignments	Instructional Aids
1. Thermo-electric current is formed by connecting and heating two dissimilar metals. 2. Each metal has a specific heat. Be able to determine specific heat of a particular metal. 3. Operating principle of a pyrometer and thermocouple. 4. Function of cones as used in the ceramic industry for determining firing heats.	1. Class instruction of thermocouples using aluminum, copper, brass, and steel rods. a) Connect each combination (12 in all) to a millivolt meter. Record data as to best bimetal combination. 2. Instructor demonstration - - - student recording of determining cone heat by using class constructed thermocouple and pyrometer. Olivo, pg 254 - Assignment Sheet. 3. Class discussion of INTERPRETING RESULTS, Olivo, pg. 255	1. Olivo, pg 254 Experiment "B" 2. Kelly

UNIT ON BEHAVIOR OF GASES (Objectives)

1. The students will be able to relate in writing or by oral description the Kinetic Theory of gases, producing its derivation and principles.

2. The students shall be able to describe the action of molecules in a gaseous state which eventually exert pressure.

3. The students shall be able to successfully use a pressure gauge of the manometer and bourdon type and describe the functions of each.

4. The students will be asked to conduct and/or observe temperature experiments involving gases under varying degrees of pressure - the air brakes, monsoon lung, iron lungs, etc.

5. The students shall become familiar with the purposes and use of vacuums, vacuums pumps and tubes.

6. The student will exhibit an understanding of "Boyles Law" and "Charles Law" with the mathematical description of these two laws.

7. The student will be required to manipulate and give the derivation of the "Ideal or General Gas Law:" while relating this Law to problems of temperature and pressure changes in gases.

8. The student will become familiar with and be able to define "Absolute or Kelvin Temperature Scale."

9. The student shall be required to distinguish internal and external combustion engines by giving examples of each and describing their operation. This shall include the relation of the internal combustion engine to the laws of gases and to the conversion of BTU to horsepower.

10. The student shall be able to describe the principles involved in:
    - a) The steam turbine
    - B) The Gas Turbine
    - C) The Air Conditioner
    - D) The Refrigerator
    - E) The Ram-Jet Engine
    - F) The Rocket

REFERENCES:

BLACKWOOD, HERRON, KELLY - HIGH SCHOOL PHYSICS, pgs. 246-270
E. SUTTON - DEMONSTRATION EXPERIMENTS, pgs. 107, 205-213
H. SEMAT - PHYSICS IN THE MODERN WORLD, pgs. 155 -158
E. ROGERS - PHYSICS FOR THE INQUIRING MIND, Chapt. 25

UNIT ON HEAT TRANSFER (Objectives)

1. The students shall be able to describe the movement of heat in the terms of convection, conduction and radiation.

2. The students will demonstrate, by simple experiments in class, the movement of heat in convection.

3. The students will be able to cite some everyday illustrations of the effect of convection in the home, in industry, etc.

4. The students will demonstrate in class, by simple experiments the movement of heat due to conduction. The students will then be able to define conduction while giving practical illustrations of this phenomena.

5. The students will demonstrate the differences between convection, conduction and radiation. They shall be required to demonstrate the uses of radiation and as they appear in our environment.

6. The student will be able to distinguish between conduction, convection, heat absorbers, emitters, insulators and radiation.

7. The students shall construct a class project to illustrate these three types of heat transfer.

REFERENCES:

BLACKWOOD, HERRON, KELLY - HIGH SCHOOL PHYSICS, pgs. 280-294

E. SUTTON - DEMONSTRATION EXPERIMENTS, pgs. 230-237

E. ROGERS - PHYSICS FOR THE INQUIRING MIND - pg. 73

UNIT ON FREEZING AND MELTING (Objectives)

1. The students shall demonstrate the ability to describe and compare the behavior of molecules in the three states of solids, gases, and liquids, in terms of the Kinetic Theory.

2. The student shall be able to describe freezing and melting in terms of the formation of crystals by the Molecules.

3. The students shall compose a list of specific substances denoting their melting and freezing points.

4. The students shall be able to distinguish between the behavior of crystals and non-crystal compounds under conditions of freezing and melting.

5. The student shall exhibit an understanding and present illustrations and some applications of the peculiar properties of water in freezing and melting.

6. The student shall be able to define the term "fusion" and what is meant by the heat of fusion while using the formula as an aid to solving problems involving melting of substances and compounds.

7. The student will be asked to describe the useful and harmful effect of water when it freezes.

8. The student will be able to demonstrate an understanding of the term "evaporation" and cite the principles related to it.

9. The student shall describe the action of "Vapor Pressure" and be able to cite some illustration of this principle.

10. The student will be able to find the heat of vaporization of a liquid in a class demonstration.

11. The students will be able to describe the vaccum coffee maker in terms of vapor pressure and atmospheric pressure.

12. The student will be asked to describe the functions of a steam heating system, a mechanical refrigerator and a heat pump.

REFERENCES:
BLACKWOOD, HERRON, KELLY - HIGH SCHOOL PHYSICS, pgs. 281-315
H. SEMAT - PHYSICS IN THE MODERN WORLD, pgs. 148-'54
E. SUTTON - DEMONSTRATION EXPERIMENTS, pgs. 212-220

UNIT ON HEAT Experiments)

1. The students shall complete the two units on heat in their laboratory manual which concentrate on HEAT.

2. The students shall demonstrate by the use of a linear-expansion apparatus the coefficient of expansion. The materials shall consist of the apparatus, meter stick, thermometer and a burner.

3. The students shall construct an apparatus illustrating the effect of gas pressure on a static, enclosed amount of fluid.

4. The students shall experience the classic experiment as described in their manual of Boyle and his Law.

5. The students shall become familiar with the operations of internal combustion engines in the tech-lab.

6. The students shall use a calorimeter to calculate, identify, and define, specific heat.

7. The students shall be demonstrated the operation of a heat transfer unit .....water heater, refrigerator.

8. The students shall use a calorimeter in their experiment to demonstrate the heat of fusion, recording all data, and conclusions.

9. Finally, the students shall make use of the calorimeter to measure the heat of vaporization.

UNIT ON SOUND (Objectives)

1. The students shall be able to define compression and rarefaction as they are related to sound.

2. The student shall be able to precisely define the term "sound."

3. The students shall be able to demonstrate that sound travels at different speeds depending on the medium through which it travels. The students shall be given the illustration of the vacuum and how it affects sound.

3. The students shall become aware and exhibit an understanding of how the velocity of sound was estimated and how this velocity is proportional to the medium through which the sound travels.

5. The students shall be able to explain the reflection of sound and be able to demonstrate some illustrations of this reflection.

6. The students shall be asked to examine some examples of this reflection, i.e.; a bat, sonar gear on a submarine, telestar.

7. The students shall become familiar with the physical properties of the human ear and be able to define hammer, anvil, stirrup, as they are related to this mechanism.

8. The students will be able to define vibrations, compression, echo, and rarefaction as they are related to the human ear.

REFERENCES:

BLACKWOOD, HERRON, KELLY - HIGH SCHOOL PHYSICS, pgs. 367-376

E. SUTTON - DEMONSTRATION EXPERIMENTS, pgs. 154- 177

E. ROGERS - PHYSICS FOR THE INQUIRING MIND, pgs. 180. 364, 389, 444, 476

UNIT ON VIBRATIONS AND WAVES (Objectives)

1. The student shall be able to define "vibrations" and "frequency" and be able to explain the differences between these two physical forces.

2. The students will then perform the experiment using the pendulum to estimate the time necessary for one period of the pendulum i.e. the vibrations of the pendulum, as it is used in the textbook.

3. The student will become familiar with the formula for finding the vibrations of the pendulum as it is used in the text book.

4. The student shall be able to explain or define a "wave" and the "wave length" by demonstration or in written form.

5. The student will be able to define amplitude and frequency as they are related to the wave length.

6. The students will be required to recognize the difference between wave transverse and wave compression.

7. The students shall have an awareness of the difficulties of estimating wave velocities and some knowledge of the experimental basic principles upon which the velocities now rest. (V - Fx W L)

8. The students shall explain some common, everyday extension of the wave theory using water, musical instruments, a truck passing and window shaking, a jet overhead.

REFERENCES:

BLACKWOOD, HERRON, KELLY - HIGH SCHOOL PHYSICS, pgs 356-366

E. SUTTON - DEMONSTRATION EXPERIMENTS, pgs. 137-156

H. SEMAT - PHYSICS IN THE MODERN WORLD, pgs. 243-247

E. ROGERS - PHYSICS FOR THE INQUIRING MIND, pgs 176-183

UNIT ON MUSIC AND MUSICAL INSTRUMENTS (Objectives)

1. The student will be able to adequately define the differences between sound and noise. This definition will require a striker definition of vibrations to be operative.

2. The student will be able to define the difference between intensity and loudness of a sound and be able to use molecular action as a basis for this definition.

3. The student shall become aware of how the measurement of sound (BEL) has performed and be able to explain this method.

4. The students shall be able to define the difference between "pitch" "interference" and "beat."

5. The students shall be able to explain the "Doppler Effect" as it is used in sonar.

6. The students shall be able to express the laws of vibrating strings and solve some practical problems using these laws.

7. The students shall be exposed to a survey of musical instruments and be familiar with how musical instruments are tuned.

8. The student will be able to define "harmonics" either in written form or orally and be familiar with the uses of a sonometer.

9. The student shall be familiar with the term "harmony" and be ready to explain the derivation of this term and its meanings.

10. The student shall be able to discuss the elements of the human voice and be able to explain the differences (physical) between the voices of men and women.

REFERENCES:

BLACKWOOD, HERRON, KELLY - HIGH SCHOOL PHYSICS, pgs. 377-398

E. SUTTON - DEMONSTRATION EXPERIMENTS, pgs. 179-182

O. LUHR - PHYSICS TELLS WHY, pgs. 238-245

THE TECH LAB - De Anza High School - - Statement of Purpose.

The Tech Lab will function primarily as a reinforcing situation where students will construct test equipment and models to better express certain scientific functions. Shop skills will be taught incidentally to primary purpose.

The learning units in the Tech Lab will parallel in content - the learning unit in the physics class. This will be accomplished by the use of a day-by-day planning chart on which is recorded the units being covered in science and English.

The laboratory will furnish the tech-English with nomenclature for tools, machines and materials being used to meet the in-product of sciene and math understanding. Topics for reports pertinent to concepts, equipment, material and test results will be provided the students in order that they may learn to express themselves scientifically. These reports and nomenclatures will be part of their English requirements in conjunction with laboratory content.

In brief, this laboratory will be a program oriented to problem solving rather than a project centered program that is designed to develop shop skills. It will differ from the traditional shop program in that every effort will be made to integrate the course content with that of science, English and mathematics and drafting.

PRE TECH ENGLISH - - Statement of Purpose

This course is intended for students who plan to enroll in a technical institute following high school graduation. The content of the course has been selected to appeal to the interest of these students and to provide the communicative skills necessary for their future technical educational needs. This course differs from the traditional eleventh grade English offering in that it is integrated with physics, mathematics and the tech lab. This inter-departmental approach should appeal to the student and impress upon him the necessity for effective communication. Also, a cooperative approach should capitalize on the technical interest of the students and provide reinforcement in learning.

Activities will be oriented toward the work of the technician. The term paper or term report will be replaced by the "technical report." Vocabulary study will utilize terms and phrases from physics, mathematics and the technical laboratory. Grammar will be studied for its contribution to effective communication rather than its existence as a body of rules. Learning aids will be employed as motivating devices in order to capitalize on the mechanical interest of the students and to present the study of English in a new framework. These aids will include program instruction, telephone mock-ups, photo copy, projectors, tape recorders, dictaphones and role playing.

PRE-TECH ENGLISH

TOPIC: INTEGRATION

In the English class the students will study:

1. History of measurement (tech lab, physics)
2. History of science (physics)
3. Industrial Revolution (social studies, physics, tech lab)
    - a) patents, copyrights
    - b) standardof living
    - c) capitalism
    - d) automation

For each unit in physics, tech lab and mathematics, the instructors will cooperatively develop a vocabulary list. The words and phrases on this list will be studied in English before the unit begins. There will be a concerted effort on the part of the teachers to use these terms; also, each teacher will expect the students to master these terms.

In addition, for each unit, there will be topics assigned for individual oral reports. Each student will be required to do several oral reports during the year for informational purposes, e.g., lubrication, antifriction, bearings.

OBJECTIVES:

Each student will:

1. Learn to locate information
2. Master and organize the material
3. Communicate this information to the class
4. Help evaluate the oral reports and the reception and understanding of these reports

OTHER SUBJECT AREAS WITH ENGLISH

Each instructor will require effective communication. The student will be expected to express himself lucidly and accurately in all classes at all times and not just in the English class.

The student will be encouraged to use the language accurately and effectively. Each assignment will be checked for grammar, spelling, and mechanics, as well as for technical accuracy. Sometimes this will be done cooperatively by the English instructor and the tech lab instructor, for example; and sometimes by the instructor involved.

There will be a conscious attempt to blur subject lines. The emphasis will be on learning and the integration of subject areas rather than on making a mark in English, physics, etc.

PRE-TECH ENGLISH

TOPIC: COMPOSITION - Units of Study

1. Introduction
   - a. Why study English?
   - b. The importance of communication.
   - c. Precision in Science and Communication.

2. Writing Effective Paragraphs
   - a. The Big Idea (topic sentence).
   - b. Unity

3. Writing Compositions
   - a. Outlining
   - b. Prècis writing
   - c. Paraphrasing

4. Writing the Technical Report
   - a. Letters
     - 1) Technical
     - 2) Transmittal
     - 3) Application
   - b. The informal report.
   - c. The progress report.
   - d. The information report.
   - e. The inspection (trip) report.
   - f. The problem-solution report.

BIBLIOGRAPHY (Students)

Unit I	General Electric's Answer to 4 "Why's."
Unit II-III	Warriner, John E. HANDBOOK OF ENGLISH, Book II Harcourt, Brace and Co., New York, 1951.

Unit IV Richardson, Ralph A. and C. A. Brown -
HOW TO ORGANIZE AND WRITE EFFECTIVE TECHNICAL REPORTS.
Reprint from *General Motors Engineering Journal,*
Vol. 2 - No. 5, Sept.-Oct. 1955

BIBLIOGRAPHY - (References)

Crouch, W. George and Robert L. Zetler. A GUIDE TO TECHNICAL WRITING,
Ronald Press, New York, 1954.

Gaum, Carl G.; Harold F. Graves; and Lyne S. S. Hoffman, REPORT WRITING,
Prentice-Hall, New York 1951.

Shuman, John T. - ENGLISH FOR VOCATIONAL AND TECHNICAL SCHOOLS.
Ronald Press, New York, 1954.

Tracy, R.C. and H.L. Jennings - HANDBOOK FOR TECHNICAL WRITERS.
American Technical Society,
Chicago, 1961.

PRE-TECH ENGLISH

TOPIC: COMPOSITION - (Objectives)

Objectives:

1. The pupil will be able to:
   1) Write a sentence which is grammatically correct and which transfers a thought from writer to reader.
   2) Locate the "Big Idea" (central thought or topic sentence) in a paragraph.
   3) Write a paragraph when given a "Big Idea."

2. The pupil will be able to:
   1) Outline a brief essay by locating the Big Idea in the paragraphs.
   2) Make an outline when given a subject.
   3) Write a composition from an outline.
   4) Paraphrase a given passage.
   5) Write a precis of a given section of writing.

3. The pupil will be able to:
   1) Write a technical report which is grammatically correct, in proper form, is accurate and cannot be misinterpreted.

COMPOSITION

During the first semester, the emphasis will be on precision in communication. The pupils will learn to write effectively. They will be able to make one idea the property of two or more persons.

The pupils will write on subjects of interest to them. They will move toward technical writing in the first semester (e.g. writing a composition describing an experiment in physics or tech-lab). The pupil will help determine how much composition he does. The teacher and the pupil will work together to increase the compositions so that he can evaluate his progress.

In the second semester the pupil will learn to write technical reports. He will work on form first, - then style.

PRE-TECH ENGLISH

TOPIC: GRAMMAR - (objectives)

Objectives:

The pupil will:

1) Learn how grammar contributes to coherence in communication.
2) Practice language activities rather than learn a body of abstract rules and principles.
3) Practice writing skills which are closely related to daily life.
4) Understand and be able to use the mechanics of communication.
5) Learn how grammar provides an essential knowledge of words, word order, and word relationships.

GRAMMAR

The pupils will review the basic rules of grammar and will refer to them as they need them in writing. The major emphasis will be on effective writing and the part played by the study of grammar in effective writing. The pupils will recognize that effective sentences are grammatically correct.

METHOD OF STUDY - Texts

Blumenthal, J.C. - ENGLISH 2600. Harcourt, Brace; New York.

Warriner, John E. - HANDBOOK OF ENGLISH, Book II, Harcourt, Brace: NY 1951

The pupils will use ENGLISH 2600 as a review and self-teaching device. During the first quarter there will be achievement tests every week (or about every 400 frames). The HANDBOOK of ENGLISH will be used for reference or referral.

PRE-TECH ENGLISH -

UNITS OF STUDY

1. The Short Story - Jack London "TO BUILD A FIRE" - pp. 404-416
2. Poetry

   Markham, Edwin - "THE MAN WITH THE HOE" - pp 228-231.
   Cullen, Countee - "YET DO I MARVEL" - pp. 241-242.
3. The Essay -
   Ralph Waldo Emerson - "SELF-RELIANCE" - pp. 613-617.
4. Biography - Allan Nevins - "HENRY FORD BUILDS A HORSELESS CARRIAGE" - pp. 142-155.

TEXT

McCarthy, Al. L. and Delmer Rodabaugh - PROSE AND POETRY OF AMERICA.
L. W. Singer and Co., Syracuse, New York, 1955.

These were selected to illustrate excellent writing as well as to capitalize on the interests of young men in a technical society. For example - Jack London's short story will be discussed and critically analyzed from the point of view of man's struggle with nature. This will bring new "insight" to the study of the history of science, the industrial revolution and automation.

OUTSIDE READING ASSIGNMENTS

1st Quarter

Miller, Arthur - THE DEATH OF A SALESMAN

2nd Quarter

Each pupil will select a biography of an American who contributed significantly to the industrial revolution in the United States, (e.g., Ford, Whitney, Westinghouse, Steinmetz, Edison, et cetera).

3rd Quarter

Each pupil will select a novel dealing with the future of the industrial revolution, (e.g., Huxley's BRAVE NEW WORLD, - Bellamy's LOOKING BACKWARD, et cetera.

4th Quarter

Each pupil will read either: Twain, Mark - THE ADVENTURES OF HUCKLEBERRY FINN or Melville, Herman - MOBY DICK.

Portions of these novels will be paraphrased. Other portions will be utilized in precis-writing.

PRE-TECH ENGLISH

TOPIC: Literature

Objectives:

The pupil will:

1. Read widely in the field of American Literature.
2. Become familiar with the various forms of American Literature.
3. Read and discuss some of the great literature of the UnitedStates.
4. Read literature for the experiences it presents and the ideas it has to offer.
5. Learn about the history and ideals of the United States as they are reflected in our literature.
6. Understand (and will be able to express this understanding) the industrial revolution, its impact on the United States and the world, and some of the problems which accompany it; and to fully be aware of the differences between the industrial revolution and the age of automation.

LITERATURE

The major emphasis in this class will be on stimulating reading and discussing the content. The pupils will be encouraged to do independent reading. The required reading will be kept to a minimum and it has been selected for its interest to the young men who are interested in technology.

PRE-TECH ENGLISH

TOPIC: VOCABULARY - Word Attack

The Greek Alphabet will be taught because of the extensive use of Greek characters in engineering and mathematical formulas. The student should be aware of the important contributions made by the Greeks in the fields of mathematics, philosophy, and physiology. He will see Greek spelling of root words in his dictionary usage and will thereby develop a further appreciation for their alphabet. He should learn both cursive and printed forms since they are both in common usage in the field of engineering.

Vocabulary studies will be conducted on a systematic approach rather than rote memorization of previously prepared word lists.

First, word lists will be taken from the various technical areas as the student develops a need for them. In addition, non-technical words will expand his vocabulary as the student develops need for a more adequate, usable vocabulary.

Secondly, words will be studied using many approaches in order to make them truly a part of the student's vocabulary and to encourage his interest in words and the building of an adequate vocabulary for more accurate and effective communication.

Finally, by examining words using all of the above methods, the student will develop a systematic approach to word attack that will provide him a useful tool in the further expansion of his vocabulary.

The necessity for precision and accuracy in scientific communication will emphasize the need for a varied and voluminous vocabulary.

Word study will be a daily routine, developing a short list of technical, general usage words for study purposes. The pupil will then be tested weekly on his mastery of these words.

CONTENT

1. Greek Alphabet
    a) Printed
    b) Cursive
    c) Upper case
    d) Lower case

2. Pronounciation
    a) Dictionary
    b) Discritical markings
    c) Analysis of speech sounds
    d) Phonics
        1) clues
        2) blends
        3) syllabilification

3. Recognition
    a) Context
    b) Compound words
    c) Auditory-phonics
    d) Structural
        1) prefix
        2) suffix
        3) root word-stem
            a. Greek
            b. Latin
            c. Anglo-Saxon
    e) "is" and "ei"
    f) Plurals
        1) "o" ending
        2) "f" and "fe" endings
        3) foreign words
        4) possessives - singular and plural forms

    - g) Hyphened words
    - h) Abbreviations

4. Drill Activities
    - a) Dictionary
    - b) Word Lists
        - 1) demons
        - 2) vocabulary extension
        - 3) technical (supplied by other areas of program)
        - 4) R.U.H.S. spelling lists

5. References

    - a) Word attack - Roberts
    - b) Word studies - Walter and Lang
    - c) Living Words - Radke
    - d) Winning Words - Christ
    - e) Vocabulary Quiz - Gilmartin
    - f) Word Wealth - Miller

PRE-TECH ENGLISH

TOPIC: SPEECH UNIT - Content

1. Introduction

    a. Importance of speech in a democracy
    b. Importance of speech in conversation
        1) enjoyment
        2) enrichment
        3) companionship
        4) story telling
        5) good impression on others

    c. Business
        1) telephone (record telephone conversations with tape recorder)
        2) interviews (counselor in role of personnel interviewer - student supplies personal profile)
        3) dictation (student is checked out in the use and application of a dictaphone)

    d. Sales and Technology

    e. Communicating ideas
        1) explanations
        2) descriptions
        3) instructions
        4) suggestions
        5) opinions

    f. Importance of listening

2. Pronounciation

    a. American speech sounds
    b. Authority
    c. Deviations
    d. Individual speech sounds
        1) diacritical markings
        2) phonetic symbols (I.P.A.)
        3) analysis of formation
    e. Articulation
    f. Practice - word lists

3. Preparing a Speech

- a. Choosing a subject
    - 1) personal interest
    - 2) listener interest
        - a) "Drives"
            - (1) safety, security and comfort
            - (2) recognition, dignity, and self-respect
            - (3) adventure and curiosity
            - (4) reverence (heroes, tradition and diety)

- b. Choosing a central theme
- c. Choosing a purpose - sentence
- c. Selecting two or three main points
    - 1) Orders
        - a) time
        - b) space
        - c) classification
        - d) cause and effect
        - e) problem - solution
        - f) make straightaway statements
    - 2) Using specific and interesting material to support points
        - a) illustrations
        - b) comparisons and contrasts
        - c) facts and figures
            - (1) meaningful and sparingly
            - (2) verification
        - d) humor and discretion
        - e) concrete words
        - f) colorful words
        - g) omission of superfluous words
    - 3) Outlining
        - a) purpose - sentence
        - b) introduction
            - (1) get attention and good will
            - (2) orient listeners
                - (a) present subject
                - (b) background facts
                - (c) speaker's point of view
        - c) body
            - (1) limit to two or three main points
            - (2) organize to some thought pattern
            - (3) consider audiences attitude
                - (a) acceptance - be vivid, impressive or dynamic
                - (b) doubtful - be informative

- (c) opposed - use facts, be conciliatory and impelling
- (d) indifference - impel by motivation

4. Delivery

   a. Types
      1) reading from manuscript
      2) memorizing
      3) extemporizing
      4) combining extemporaneous with written
   b. Body
      1) posture
      2) movement
      3) gesture
   c. Voice
      1) purity
      2) normal pitch
      3) strength
      4) flexibility
      5) inflection
   d. Evaluation
      1) self (using tape recorder
      2) class
         a) individual
         b) group
      3) teacher
      4) criticism sheet

5. Reasoning

   a. Inductive (scientific method)
      1) generalization
      2) analogy
      3) causal relationship
         a) effect to cause
         b) cause to effect
         c) effect to effect
      4. deductive
      5. fallacies
         a) ignoring the question
         b) begging the question
         c) hasty generalization
         d) false analogy
         e) mistaken causal relationship

6. Social graces

   a. Conversation
      1) everyday
      2) introduction
      3) telephone
      4) social
      5) business

   b. Business etiquette
   c. Table manners
   d. Acknowledgements
   e. Etiquette in the company of the opposite sex
   f. Grooming

7. Parliamentary Procedure

   a. Purpose
   b. Conducting a meeting
      1) organizing a group
      2) election of officers
      3) constitution and by-laws
   c. Order of business
   d. Motions
      1) kinds
      2) form
      3) precedence

PRE-TECH ENGLISH

TOPIC: STUDY SKILLS UNIT - Content

1. Reading

    a. Varying method to purpose and material
    b. Varying rate to purpose and material
    c. How to increase reading rate - comprehension

2. Library skills

    a. Parts of a book
    b. How to locate books
        1) card catalogue
        2) location
            a) faction and non-fiction (simplified Dewey Decimal System)
            c) reference
        3) obtaining information
            a) dictionaries, encyclopedias, perioicals
            b) Atlas and Gazeteers
            c) biographical reference books

3. Environment

    a. Physical environment
    b. Mental attitudes

4. Class discussion and lectures
    a. Value of class participation - note taking
    b. Value of teacher-pupil converences

5. Preparing assignments

    a. Methods
    b. Principles of recall
    c. Budgeting time

6. Studying for examinations

7. Methods used in science

    a. How information is obtained, recorded, presented
    b. How to carry on investigations

FORM FOR REPORTS

General Information

The report must be either typewritten and double spaced or lettered. Writing must appear on one side of the paper only. The report is to be placed in a folder.

The main parts of the report are:

1. Title Page
2. Letter of Transmittal
3. Table of Contents
4. Summary
5. Text
6. Bibliography

Each part of the report is to be on a separate page, and the pages are to be numbered at the upper right-hand corner.

1. TITLE PAGE

The title page contains: subject; submitted to; submitted by; and the date. Each item will take approximately 1/4 of the page. The subject is in caps. The date is the same as that on the letter of transmittal.

2. LETTER OF TRANSMITTAL

The function of the letter of transmittal is to:

1. State the reason for writing the report
2. Point out specific parts of the report
3. Give credit to sources other than printed material
4. State difficulties encountered

3. TABLE OF CONTENTS

A table of contents gives the subject and the first page on which the information appears. Page numbering of the report starts after the table of contents.

4. SUMMARY, INTRODUCTION, or INTRODUCTORY SUMMARY

A summary gives a brief picture of the contents of the report. An introduction gives background material for the report. An introductory summary is a combination of the two.

The student must have a summary at the beginning of the report. He may also have an introduction, or he may combine the two into an introductory summary.

5. TEXT

In the text, the headings are designated in the following manner:

FIRST HEADING---all letters are capitalized
SECOND HEADING---only the first letter of each word is capitalized
THIRD HEADING---only the first letter of the first word is capitalized

The first page of the text should start about 3 inches from the top of the page. All other pages of the text should start about 1 inch from the top of the page. All pages of the text should have bottom and side margines of approximately 1 inch.

6. BIBLIOGRAPHY

The bibliography contains all printed sources of information. Sources of information other than printed sources should be noted in the letter of transmittal.

Entries in the bibliography are single spaced with double spacing between and are entered in alphabetical order. Magazines, books, and pamphlets are not separated.

The following information is given for magazines:

> Author, title of article, title of magazine, volumen, number, date and page(s).

FOR EXAMPLE:

Anonymous, "Letter Writing," NEWSWEEK. Vol. 15, No. 1, March 1961, pp. 15-16 (Magazine)

Curl, Marvin J., EXPOSITORY WRITING, Rev. ed. Boston: Houghton-Mifflin Co., 1931, p. 10 (Book)

Hardy, Robt. C., "Modern Controls," SCIENTIFIC AMERICAN. Vol. 3, No. 7, March, 1961, p.31. (Magazine)

FOOTNOTES

Every direct quote MUST have a footnote. Footnotes should give the author's name, the title of the work and the page number: for example:-- Mervin Curl, EXPOSITORY WRITING, p. 10.

PRE-TECH MATHEMATICS - De Anza High School
(11th and 12th grades)

TOPIC: OBJECTIVE

The objective of this course is to provide an adequate proficiency in high school algebra, geometry, and numerical trigonometry for the student who intends to enroll in an engineering technical institute.

The basic objective of the technical institute is to give a practical working knowledge of fundamental principles in a selected field. Calculus and analytic geometry are NOT usually included in their curricula, but rather, applied mathematics for specific technology is taught. Mathematics plays a major role in the technical institute program, but established procedures and formulas are emphasized.

Therefore, in the two-year pre-technician's mathematics program the following subject matter will be presented: - skill in the use of the slide rule; tables and common logarithms for calculation and trigonometry; speed and accuracy in arithmetic; a course in algebra through quadratic equations with graphical and algebraic solution of systems of equations; a knowledge of definitions, theorems, and formulas of plane geometry; and a course in plane trigonometry in solving right and oblique triangles, with a brief introduction of trigonometric identities and inverse functions.

Also, whenever possible, problems will be taken from and related to the Pre-technician's Physics Course.

PRE-TECH MATHEMATICS

TOPIC: OUTLINE FOR TWO YEAR COURSE

11th Grade

Part 1	Use of slide rule. Calculation (including review of arithmetic. Problems from physics and geometry. Numerical trigonometry. Simple vectors
Part II	Graphs and simple statistics,
Part III	Algebra through quadratic equations. NOTE: First part is review.

12th Grade

Part IV	Logarithms, NOTE: Emphasis placed on use in physics and engineering type of problems
Part V	Systems of equations (linear and quadratic). Graphical solutions. Algebraic solutions. Determinants. Use of equations in solving certain word problems.
Part VI	Plane geometry. Brief course in definitions, theorems, formulas.
Part VII	Plane trigonometry. Right and oblique triangles. Identities and inverse functions (brief introduction). More work on vectors. NOTE: Emphasis on the use of logarithms, tables and slide rule in solving triangles.

PRE-TECH MATHEMATICS

TOPIC: Course Titles

I. 11th grade - Algebra 2 (T)

II. 12th grade - Trigonometry - Mathematics Analysis (T)

Pre-technician's mathematics is a course of study for students who are going to a two-year technical college. Therefore, other subjects besides algebra and trigonometry are taught in the course. On the permanent records cards, in the 11th and 12th grades, only Algebra 2 (T) and Trigonometry - Mathematics Analysis (T) can be entered for college preparatory students.

Parts I and II

The purpose of Parts I and II is to teach mathematical skills necessary to do any work encountered in physics or shop. Therefore, the slide rule work, the arithmetic review, the numerical trigonometry and the graphs are studied before algebra (Part III).

PART I

All problems from Unit I to Unit 16 are from the booklet THE SLIDE RULE, by John K. Grimason.

1. Parts of a slide rule
    a. Finding numbers on the "C" and "D" scale.
    b. Significant figures.
    c. Discussion of the uses and limitations of the slide rule.
2. Using the slide rule to multiply.
    a. Problems, page 10.
3. Using the slide rule to divide
    a. Problems, page 11
4. Estimating decimals in slide rule work.
    a. By Estimation
    b. By Scientific notation.
    c. Problems on ditto sheets.
5. Changing fractions to decimals.
    a. By slide rule
    b. By arithmetic
    c. Problems, page 12
6. Changing decimals to fractions.
    a. By slide rule
    b. By arithmetic
    c. Problems, page 13
7. Percentage using a slide rule.
    a. Problems, Page 14
    b. Problems on a ditto sheet
8. Using the slide rule for proportion
    a. Problems, page 15
    b. Problems on a ditto sheet
9. Adding, subtracting, multiplication, division with fractions (review) (This is not slide rule work.)
    a. Prime numbers, factors
    b. Use of reciprocals
    c. Addition and subtraction of fractions
    d. Problems on ditto sheets
10. Complex problems.
    a. Problems, page 17
    b. Problems on ditto sheet (from physics course)

11. Squaring a number with the slide rule
    a. Problems, page 18

12. Finding the square root of a number with the slide rule
    a. Problems, page 20
13. Finding the cube root of a number with the slide rule
    a. Problems, page 21
14. Using the slide rule to solve problems from physics and geometry (areas and volumes)
    a. Several ditto sheets of problems. (Emphasis on formulas used in these areas. Also, many problems will be given to increase ability to use slide rule accurately.

In units #16 through #20, Chapter 14, the text book, MODERN ALGEBRA, STRUCTURE AND METHOD, Book I, by Dolciani, Berman and Freilich, is used.

15. Geometric assumptions, rays, and angles
    a. Problems, Pages 497-498
16. Similar triangles
    a. Problems, pages 500-501
17. The tangent function
    a. Problems, pages 503-05 (using tables in text
    b. Problems, page 24 - slide rule text
    c. Problems from ditto sheet (using slide rule)
18. The sine and cosine functions
    a. Problems, pages 505-506 (using tables in text)
    b. Problems, page 23 - slide rule text
    c. Problems from ditto sheet (using slide rule)
    d. Problems, pages 507-508 (using slide rule)
19. Working with vectors
    a. Problems, pages 511-512 (using slide rule)
    b. Problems, pages 513-514 (using slide rule)

PART II - Statistics and Graphs

(The textbook for this unit will be a pamphlet taken from S.M.S.G., vol. 1, Book 3, Chapter 13, revised edition.)

1. Broken line graph
2. Bar graph
3. Circle graph
4. Summarizing data
    a. Mode
    b. Median - Mean
    c. Grouping data
    e. Average deviation
    f. Sampling

PART III

The text book used in Part III is MODERN ALGEBRA, STRUCTURE AND METHOD, by Dolciani, Berman, and Freilich.

The students in this class have a wide range of ability and achievement in algebra. Some students have studied no algebra. Some have passed ninth grade algebra with poor grades and some have made excellent grades. All students are to take an algebra achievement test at the start of the course and, depending on the results of the test, the students will be separated into three groups.

A feature of this text book is that most sets of exercises are split into three groups: "A", "B", and "C". This grouping provides for individual differences in students. "A" group is a set of simple exercises. "B" group is for students with greater ability. "C" group is aimed to challenge the very best students.

The students in this course, being at an 11th grade level, should be able to proceed at a rapid pace through the exercises. Therefore, any of the beginning exercises will be touched on only briefly. Extra time will be spent on verbal problems, of which the text has an excellent selection. Also verbal problems will be taken from the physics course. Tests will be made up from the chapter tests and chapter reviews.

The text book uses the modern mathematics approach, so much of the language used is similar to the type used in S.M.S.G. text books.

The list following contains the major subdivision of each chapter that the class will cover.

1. Numbers and their relationships.
   Grouping numbers in sets and subsets.
   Using numbers in one or more operations.

2. Analyzing algebraic statements.
   Problems solved with variables.

3. Identifying and using number axioms.
   Transforming equations with equality properties.

4. Extending the number line.
   Operating with directed numbers.

5. Open sentences in the set of directed numbers.
   The analysis of problems.

6. Addition and subtraction of polynomials.
   Multiplication of polynomials.
   Division of polynomials.

7. The distributive property in factoring.
   Quadratic trinomials.
   Extension of factoring.

8. Fractions and ratios.
   Multiplying and dividing fractions.
   Adding and subtracting fractions.
   Fractions in open sentences and problems.

9. Ordered pairs of numbers and points in a plane.
   Linear equations and straight lines.
   Inequalities and special graphs.

10. Solving systems of linear open sentences.
11. The system of rational numbers.
    Irrational numbers.
    Radical expressions.

12. Functions and Variations.
    Selecting pairs of numbers.
    Variation.

13. General methods of solving quadratic equations.
    The solution of quadratic inequalities.

PART IV

The text book used is TRIGONOMETRY WITH TABLES, by Welchons and Krickenberger. Subdivisions are as follows:

1. Meaning of logarithms.
   Problems - page 58

2. Common logarithms.
   Problems - pages 61-63

3. Find logarithms and antilogarithms of any four digit number.
   Problems - pages 65-68

4. Computing with logarithms.
   Problems - page 72

5. Use of cologarithms.
   Problems - page 72

5. Use of cologarithms.
   Problems - page 73

6. Interpolation.
   Problems - pages 75, 76

7. Computations with logarithms.
   Problems - pages 77, 78
   Problems from physics on ditto sheets.

PART V

The text book for this section is ALGEBRA, BOOK TWO, by Welchons, Krickenberger and Pearson.

This section covers systems of linear and quadratic equations. The systems of linear equations are reviewed.

1. Graphical solution of two linear equations - Problems page 163.
2. Algebraic solutions of two linear equations - Problems page 166.
3. First degree equations in three variables - Problems page 168 .
4. Solving problems with two unknowns - Problems pages 174-180.
5. Graphing a quadratic function (review) - Problems page 248.
6. Y-intercept, maximum and minimum values, axis of symetry. Problems page 249-253.
7. Graphical solution of quadratic equations - Problems page 256.
8. Completing the square (review) - Problems page 262.
9. Quadratic formula (review) - Problems page 266.
10. The graph of the parabola - Problems page 348.
11. The graph of the circle - Problems page 349.
12. The graph of the elipse - Problems page 350.
13. The graph of the hyperbold - Problems page 352.
14. Graphical solutions of equations - Problems page 355.
15. Algebraic solution of one linear and one quadratic equation. Problem - page 356.
16. Algebraic solution of pairs of quadratic equations - Problems page 357-359.
17. Word problems involving systems of quadratic equations - Problems pp 361-3
18. Determinants - use in solving sets of linear equations in two variables. Problems page 421.
19. Determinants of the third order - Problems page 422-423.
20. Solution of sets of linear equations in three variables - Problems page 425.
21. Expansion of a determinant by minors - Problems page 429.

PART VI

PLANE GEOMETRY, AREAS, VOLUMES.

TEXT BOOK: Plane Geometry by Shute, Shirk, and Porter.

Plane Geometry consists of learning the basic theorems and constructions. No proofs will be required. Emphasis will be on numerical computations.

Areas and volumes consist of learning the basic formulas and working problems with the aid of the slide rule.

1. Angles - Pages 11-17 - Exercises 34 pages 17-18.
2. Axioms - Theorems - Pages 19-28- Exercises 38 page 28 (Numerical Computations).
3. Congruent Triangles - Classification of triangles - parts of triangles-pg.30. Six theorems on congruent triangles - pages 29-49.
4. Constructions - eight construction problems on perpendiculars, bisectors, angles and triangles - pages 55-61.
5. Parallel Lines
    - a. Three theorems on parallel lines cut by a transversal and the corollaries - pages 67-79.
    - b. Numerical computation - Exercises 156, page 79.
6. The Angles of a Triangle
    - Three theorems on angles of a triangle, and the corollaries, pgs 80-85
7. Quadrilaterals - Parallelograms
    - a. Six theorems on parallelograms - pages 94-102
    - b. Constructions - page 105-106
8. Mid points, Medians, and Parallels intercepting a transversal - pp 107-116
    - a. Numerical computation - Exercises 237 page 117-118.

9. Polygons
   - a. Two theorems on Polygons - pages 121-123
   - b. Numerical computation - Exercises 251 - pages 124-125.

10. Inequalities
   - a. Seven theorems and one construction - pages 126-137.
   - b. Exercise 278, page 139 (True - False test).

11. Loci
   - a. Perpendicular bisector of a line - bisector of an angle pages 41-45.
   - b. Exercise 292 - pages 146-147

12. Concurrency of attitudes, medians, and bisectors of angles of triangles
   - a. Four theorems - pages 153
   - b. Exercise 308 - page 157-158 (numerical computation).

13. Circles, Arcs, Chaords, Central angles
   - a. Definition - pages 163-164.
   - b. Five theorems and one construction - pages 165-170.

14. The Diameter and the Chord Distance to the Chords
   - a. Three theorems and one construction - page 173 - 179
   - b. Exercise 354 - True-False review test.

15. Tangents
   - a. Definitions - page 181.
   - b. Five theorems and one construction - page 182-190.
   - c. Exercises 376 - page 191-192 - Numerical computation
   - d. Exercises 378 - Review - Completion test.

16. The measurement of Angles in a circle
   - a. Definitions - page 194
   - b. Five theorems three constructions - pages 195-209.
   - c. Exercises 400 - pages 203-204 - Numerical Computation.
   - d. Exercises 409 - constructions - page 210.

17. Inequalities in circles
   - a. Four theorems - pages 212-215.

18. Proportion
   - a. Three theorems and two constructions - pages 236-241.
   - b. Exercise 459 - Numerical computation - page 242.

19. Similar triangles and similar polygons
    a. Definites
    b. Exercises 464 - page 244 - numerical computation
    c. Eight theorems and one construction - pages 244-260.
    d. Exercises 499 - page 261 - constructions.

20. Areas and Volumes from Geometry
    a. Ditto sheet listing the formulas
    b. Ditto work sheets with problems (problems to be worked with slide rule).

PART VII

The text book for this section is TRIGONOMETRY WITH TABLES, by Welchons and Krickenberger.

1. The six trigometric ratios of the sides of a right triangle - Problems page 20. Problems - page 26.

2. Reciprocal functions and confunctions - Problems pages 27 and 28.

3. Functions of 30 and 60, 45 angles - Problem - construct a table.

4. Use of tables of natural functions (review) - Problems pages 31-33.

5. Graphs of trigonometric functions - Problems - to graph the six trigonometric functions.

6. The solution of right triangles.- Problems pages 37, 41-43.

7. Solution of right triangles of logarithms - Problems pages 109-110.

8. Solving the area of any triangle by logarithms - Problems pages 111-112.

9. Using the slide rule to check problems in unite 6 and 7. (Review)

10. Trigonometric functions of any angle.
    Pages 134, 135, 136, and 140 - Problems.

11. Law of sines. Oblique triangles, case 1. Problems - page 224.
    Use slide rule.

12. Oblique triangles, case 2. Problems - pages 229-230 (Use slide rule).

13. Law of cosines. Oblique triangles, case 3. Problems - page 233. (Use slide rule).

14. Oblique triangles, case 4 - Problems page 234 (Use slide rule).

15. The law of tangents; oblique triangles - Problems page 237 (Use logarithms)

16. Areas of oblique triangles. Problems - page 249-250 (Use slide rule).

17. Vector representation. Parallelogram of forces (Use slide rule).

18. Resolution of forces - Problems page 256-258, 262-264.

19. The phythagorean relations - Problems page 187.

20. Simplification of trigonometric expressions. Problems page 188-189.

21. Proving identities. (Brief introduction) - Problems page 191.

22. Trigonometric equations. (Simple equations) Problems page 196.

23. Radian measure - Problems pages 145-146.

24. Inverse trigonometric functions. (Brief introduction). Problems pages 267-268.

PRE-TECH MATHEMATICS - Harry Ells High School

The approach to the mathematics at Harry Ells High School is based on utilizing the program instruction as developed by Encyclopedia Brittanica Films known as TEMAC. Mr. Glenn Baughman, Instructor in Mathematics at Harry Ells High School, makes the following statement: -- "Other than for the integrated portions of the mathematics where the students are taken from their TEMAC program and instructed in subject matter areas necessary for the physical sciences, the mathematics in the experimental curriculum will differ less from traditional math than the other courses in the pre-technician program. For one thing, it is hoped that all students will complete intermediate algebra and a semester of geometry - trigonometry in the four-semester period. Since the course begins with a one-semester review of elementary algebra, we have four semesters of work to do in four semesters, allowing little lattitude for elaboration of the program.

"Also, since Harry Ells is experimenting with linear program materials, the materials and sequence of the course is almost totally pre-determined by the text in use. However, the traditional materials will be augmented and supplemented as much as is practical by applications of the math to science and technology in the form of problems selected from a number of sources. In addition, there will be class time allotted as needed to serve the math needs of physics and tech lab. These procedures are outlined in the materials which follow, dealing with the integrated portion of the math program."

There will be limited instruction in the use of the slide rule, but students will be required to use it extensively for computations in the physics and tech lab. The course outline in mathematics at Harry Ells High School will be:

In addition to completing the preceding outlines, the following are the subject areas to be studied for the needs of the physics department.

1) Measurement - September 11-21 - the solution of formulas relating to the pendulum and pressure.
2) Force and friction - September 24-October 1 - simple linear formulas involving weight and math, slide rule in friction, etc.
3) Simple machines - October 5-31 - the basic algebraic formulas relating to levers, the wheel of an axle, screw, pulley, etc.
4) Motion - November 7-26 - both linear and quadratic formulas involving free falling bodies, velocities, time, distance, rate, etc.
5) Pressures in liquids - November 28 thru December 14 - simple linear formulas involving force per unit area, atmospheric pressures, etc.
6) State of matter - January 2-9 - formulas relating to mass, volume, etc.
7) Gases - January 10-18 - formulas relating to Boyle's Law, Hooke's Law, etc.
8) Tension and Elasticity - January 21 - simple linear equations relating to stress and strain.
9) Forces in Liquids - January 23-25.
10) Gravity - January 28
11) Velocity - January 29
12) Accelleration - January 30 thru February 6
13) Momentum - February 7-13
14) Gravitation - February 14-15
15) Circular motion - February 18-22
16) Energy - February 25-28 - this involves quadratic equations.
17) Heat - March 4 thru May 10 - connetic energy and co-efficient expansion, etc.
18) Sound - May 11 - involving quadratics and irrational equations.

(EXAMPLE OUTLINES - see next pages)

PRE-TECH MATHEMATICS - Harry Ells High School

OBJECTIVES FOR STUDENTS

1. To be able to pass the various unit tests on the material listed in the course content with a minimum score of 70%. (A lesser score will indicate a need for going over the material.)

2. To recognize the usefulness of each unit by being presented by the instructor with specific problems in the fields of science and engineering where the understandings and techniques of the particular unit are used.

3. To be able to score at the median level or above on a standardized test in Algebra II.

4. To score 500 points or better in the mathematics section of a college board examination.

5. To master the techniques of the slide rule to the point of doing multiple operations involving multiplication, division, squaring, and extracting square root with speed, confidence and accuracy.

6. To be able to do the math involved in physics with accuracy and speed.

CLASSROOM PROCEDURES

Each pupil will begin a TEMAC, Algebra I, at the point where he has scored less than 90% on a test, the testing beginning with Test 1A. Starting pupils with no previous experience in programmed materials other than at the beginning, may pose some problems, but is to be preferred to boring them with materials which are already mastered.

There will be a chart posted where each pupil will record each Friday:

1. the number of the last frame completed

2. the percent of response errors made during the interval from the previous recording
3. the percent score of any test taken

Students will be tested in groups of not less than ten excepting particularly slow or fast students. Consequently, slower individuals in these groups, will be urged to do extra work at home in order to cover material to meet test deadlines.

The instructor will be free for the most part to give individual help as asked for and as indicated by the percent of error on the chart.

The class will operate as a group in learning and practicing the techniques of the slide rule and in mastering the mathematics needed for physics and Tech Lab projects. Ten to twenty minutes per day of class time will be taken as needed for the math of physics.

All students will begin Algebra II together. As the students progress at their individual rates, it will nevertheless be desirable to test them in groups of not less than ten. Enrichment materials as suggested in the TEMAC Teachers Manual will be used to help pace the rapid learners. Slower learners will be given more individual help and also be encouraged to put in extra time at home in order to meet the pace of the faster group.

Perhaps the most difficult problems in organization will occur during the first semester when the review of Algebra I is being done. For the students who complete the review early in the semester, the following additional activities will be provided:

1. They will help tutor members of the class in need of special help.

2. Receive additional practice in computing with the slide rule.

3. Work from Chapter I of SMSG Algebra II to get extended experience in symbolic logic involving the commutative, associative, and distributive properties of numbers and to develop and refine manipulative skills.

ALGEBRA II (T)

This course will cover the following areas in three semesters:

1. Review of Algebra I.
2. A complete coverage of what is traditionally considered high school intermediate Algebra or Algebra II.
3. Training in the use of the slide rule.
4. Instruction and drill in the mathematics needed to work the problems occurring in Physics and Tech Lab.

The texts to be used are:

1. TEMAC Programmed Learning Materials - Algebra I and Algebra II
2. Mimeographed instruction booklet for the slide rule of John Grimason.
3. High School Physics - Blackwood and Kelly (Instructor reference only).
4. Basic Math for Science and Engineering - Andres, Miser, Reingold (teacher reference).

COURSE OUTLINE

I. Review of Algebra I

1. To renew proficiency in elementary mathematical skills by using:
    a. Algebra as an extension of the number system beyond the rational numbers to include irrational numbers.
    b. Verbal problems and formulas which depend upon the symbols and operations of algebra but which require computation using the numbers of arithmetic.
2. To develop an understanding of the properties and structure of the number system.
3. To prepare for future work in math, science, and related fields by reviews:

a. Understanding of and use of algebraic language and symbols.

b. Understanding of the sigried numbers and their operations.

c. A thorough working knowledge of formulas and equations.

d. Critical thinking and logical reasoning as a basis for lasting skill in mechanical operations.

e. The use of graphs in many fields as a means of giving precision and brevity to statements of facts and their interpretation.

II. Algebra II - Course Content

1. The real numbers and some of their properties.
    - Integers, rational numbers, and real numbers.
    - Associative, commutative, and distributive laws.
    - Operations with positive and negative real numbers.

2. Basic processes and concepts.
    - Inserting and removing parentheses
    - Order of operations
    - Positive integral exponents
    - Square root and cube root
    - Divisibility and prime numbers
    - Combining similar terms
    - Operations with polynomials

REVIEW

3. The nature of mathematical proof.
    - A formal proof of a theorem

4. Linear equations
    - Axioms which are useful in solving equations.
    - Linear equations with decimals
    - Solving for one unknown in terms of another
    - Problems involving consecutive integers
    - Age problems
    - Money and investment problems
    - Distance, rate, time problems
    - Mixture problems

5. Special products and factoring
    - The difference of two squares

Common monomial factor
Common binomial factor
Inserting or removing a minus sign in order to obtain the common binomial factor.
Squaring a binomial mentally
Perfect trinomial squares
The difference of the squares of two binomials
Factoring by grouping
Mentally finding the product of two binomials
Factoring a trinomial which is the product of two binomials
Writing an expression as the difference of two squares by adding and then subtracting the same term.
The sum and difference of two cubes

REVIEW - MIXED PROBLEMS

6. Fractions and mixed expressions.
    - Reducing fractions to lowest terms
    - Operations with fractions
    - Changing mixed expressions to fractions
    - Changing fractions to mixed expressions.
    - Multiplying and dividing mixed expressions
    - Complex fractions
    - Ratio and proportion
    - Equations containing fractions
    - Story problems involving fractional equations

REVIEW - Problems - Basic Math pp 264-265
Formula for capacitors; pp 266-267
Engineering formulas

7. Caresian coordinates
    - The real number line
    - Coordinate axes
    - Graphs of linear equations
    - Solving systems of linear equations by graphing

8. Algebraic methods of solving systems of linear equations.
    - Substitution
    - Eliminating an unknown by addition or subtraction
    - Three equations in three unknowns
    - Problems which may be solved by using systems of linear equations:

Determinants Basic Math pp 445-449
Review Basic Math p 483
(Will be covered in class to emphasize utilization by determinants as needed in Electronics)

9. Complex numbers and radicals.
    - Introduction to complex numbers
    - Simplification of radicals
    - Operations with radicals
    - Removing radicals from denominators of fractions
    - Equations containing radicals
    - Operations with square roots of negative numbers, pp 297-299
    - Power of i Basic Math p. 439 including the J factor in electronics

REVIEW

10. Functions and variables
    - Variables and constants
    - Variation
    - Introduction to functions
    - The use of sets to define function
    - Graphs of quadratic functions
    - Zeros of a function - Pasic math pp 111-112, Prob. 11, 15 pp 122-123

11. Algebraic methods of solving a quadratic equation in one unknown
    - Incomplete quadratic equations
    - Quadratic equations which may be solved by factoring
    - Completing the square as applied to structural design
    - The quadratic formula

REVIEW

Equations with radicals
The discriminant of a quadratic equation as applied to utilization of engineering handbooks
The nature of the roots of the equation
The sum and product of the roots
Problems which may be solved by using quadratic equations

12. Quadratic equations in two unknowns
    - Conic sections
    - Graphs of quadratic equations in two unknowns
    - Systems of quadratic equations

REVIEW

13. Rational exponents
    - Positive rational exponents
    - The zero exponent
    - Negative rational exponents
    - Writing numbers of scientific notation

14. Logarithms
    - Definition of logarithm
    - Logarithms of products, quotients, powers, and roots
    - Logarithms to the base ten
    - The use of a table of common logs
    - Interpolation
    - Antilogarithms
    - Calculating with logarithms
    - Equations which may be solved by using logarithms
15. The binomial theorem
    - Binomial expansions
    - The $_k$th term of a binomial expansion
    - Binomial co-efficients
    - Pascal's triangle

16. Progressions
    - Arithmetic progressions
    - The common difference
    - The $_n$the term
    - Arithmetic means as applied in definition of statistical data
    - The sum of n terms of an arithmetic progression

    - Geometric progressions
    - The common ration
    - The nth term
    - Geometric means
    - The sum of n terms of a geometric progression

REVIEW

DRAFTING AND ART DEPARTMENT

In reference to drafting and art, the 11th grade student does not receive full units in drafting or art. Limited classes are scheduled and a complete supply of drafting equipment is given each student so that he may work on assignments at home. Design or drafting problems are given to him by any number of methods. The drafting and art teachers will visit the physics lab twice monthly and give basic assignments in sketching, lettering, and use of instruments. The various other classes may also have problems in drafting and design. This method will enable the student to acquire some basic knowledge of drafting in the 11th year. The 12th year curriculum includes drafting and assignments will be in sketching, use of instruments, mechanical-architectural-engineering drawing. Related and definitely correlated with these subjects in The Richmond Plan are art and creative design.

Demands of industry for draftsmen, technical illustrators, industrial designers, electrical-architectural-mechanical draftsmen pinpoint the need for qualified technically trained men in these unlimited fields.

Art, in its most common interpretation, usually represents those associated with it as abstract, long haired, bearded Bohemians or Beatniks. Many of the present art institutions perpetuate this image, and the lay person accepts this condition.

Many of our talented and creative high school students are lost in this Bohemian clique. It is felt that these young people, if carefully guided in our secondary schools, could find a great deal of professional status utilizing their talents.

Controlled and stimulating guidance by team-teaching, and integrated subjects, will give these young people more direct encouragement in productive industries and be useful in securing employment. To further develop the potential of these young individuals, The Richmond Plan correlates the following subjects within the art department:

ENGLISH -- spelling of drafting terms; report writing of Lab and drafting assignments

PHYSICS -- experiments, graphics, drafting and art, scientific formulas

TECH LAB PROBLEMS -- design and drawing in art-drafting

Much of the visual aids used in teaching the physics and chemistry will be developed by the students in the art departments.

COMMON LEARNINGS FOR THE PRE-TECHNOLOGY PROGRAM

In addition to his primary responsibility to develop subject matter competence in the students in the experimental program of the Richmond City Schools, all of the instructors of the team have common responsibilities in the development of strong characteristics within each of these students in the following areas of:

1) Technical skill and productive capacity
2) Economic stability for all citizens
3) A conscious common loyalty to democracy
4) Respect for freedom of thought and expression
5) An understanding of the world and its peoples
6) Health and energy and the ability and will to do the work he is assigned

While the third track is primarily concerned with the subject matter skills necessary for technical institute education, the Richmond Study Group have agreed that each member is responsible to develop as fully as possible, concepts in common learnings.

Because of the homogeneous make up of the students in the third-track, the instructors feel we have the following advantages:

1) All activities (daily work, civic interest, things we think about to do) are bound up together. The teachers are not restricted to the usual subject boundaries. The way scientific inventions affect us for instance, can be better understood when an attempt is made to look at science as how it affects the social life as well as how it can be used as a physical tool.

2) Important social problems can be studied in their entirety. For instance, pupils can learn to tackle big problems as a whole - such as --- "what conditions are necessary for full employment?" By this method they can better understand the relations between the different factors such as consumer demand, money available, prices, raw materials, transportation, wages, automation, and the subject matter that they are studying at hand.

SOME PRINCIPLES OF TEACHING PHILOSOPHY FOR THE "THIRD TRACK"

A. Arousing the "Feeling of Need"

It is obvious that of all the plans of securing interest in daily class work, the simplest and most direct is that of creating in our students the "feeling of need," for the material they are studying. From the previous descriptions of The Richmond Plan, one can readily observe that it is not at all difficult to arouse the "need" because of the team-teaching approach where each teacher points out the soon to be applied knowledge of each topic.

In any successful program, all good problems are based upon situations in which knowledge is applied. Moreover, in The Richmond Plan, we require that the students actually make the application of the knowledge involved to the given case.

Finally, the teachers make frequent references to the varied uses at the Technical Institute of the knowledge that is being presented to keep his student's interest alive to their future need for it.

B. The Development of Permanent Interest

Beginning a semester before the student is selected for the "third-track" - careful attention was given to developing interest in the general fields of engineering technology by field trips to the local technical institutes, visits to the school of engineers and technicians.

C. Determing the Knowledge to be Taught

Of all the teaching skills, this one, of separating essential knowledge from that which is relatively non-essential, is one of the most difficult. The technique which the members for the third-track use, was discussed previously under "teaching methods." This method included the writing of the criterion examination before development the teaching lesson. This task of designating by name, our specific objectives (see sample lesson plans) requires the most careful thought of which we are capable. Again, as we have pointed out, "That which can be measured can be taught." We have attempted to select that material which is interesting, related to other knowledge, understandable, and usefully applied. This technique suggests that the actual classification of any given fact should be determined by some measure given to it on interest, understanding, and usefulness.

D. The Measurement of Results

The ability to repeat facts is very different from the ability to apply them in other situations. The use of the "Tech Lab" makes it easy to find methods of measuring the results of our work.

It is fitting that every educational proposal in our time be tested by comparison with the great educational objectives of our American public school system. In this report, we have listed these objectives as "Common Learnings," as endorsed by the National Education Association. Clearly, the relationship of The Richmond Plan to these objectives is obvious. We observe that the objectives all demand that the knowledge learned in school be used in later life; and this in turn makes its retention a matter of absolute necessity. In the "third track" what we have done, is speed up the necessity for immediate retention.

Students of educational psychology will find that The Richmond Plan is really centered around the three laws of: readiness, effect, and exercise; enunciated by Dr. Thorndike in his monumental work on educational psychology. We hope our program will be considered as "progressive education." Unfortunately the concepts of "progressive theory" has deteriorated into something no longer recognizable of the original.

All of us feel that the excitement we observe in our students in this program is because they recognize that we have not devised artificial devices to assist them in learning. They seem to understand that this is the "real world" and they welcome a chance to test themselves in it.

CONCLUSION

It was necessary to develop The Richmond Program around the State and local requirements currently demanded by the State and City Agencies.

It is also very gratifying to note that the cost to the District for the program, once the teachers have been trained, is not significantly greater than is normally expended. This study has proven that it is possible for a community college to accept the responsibility to develop within its own district, a high school preparatory program, leading to is own semi-professional offerings. It is obvious that it is the responsibility of the community college to assume the leadership to develop similar programs for our nation's "AVERAGE LEARNERS."

SOME NEEDS FOR FURTHER STUDY IN TECHNICAL INSTITUTE EDUCATION.

Projected employment problems of the next decade have focused attention for clearly defined occupational criteria. In this report we have used the word TECHNICIAN with the qualifying modifier "engineering." This was to clearly differentiate the engineering technician from the technician objectives of Title VIII of the National Defense Education Act.

Engineering technicians work in direct support of engineers and scientists, performing tasks that are functional parts of scientific and engineering activities. For educational curriculums to be of maximum value in planning technical education programs, they must be based on the knowledge and ability requirements of various occupations.

Occupational surveys often lead to confusion. The central concern of technical institute education should be with a body of knowledge rather than with specific jobs. While excellent technical institute programs have been offered by private institutions throughout the United States for many years, technical education in the present concept of these services is a relatively new phenomena in public education. It is obvious to those people involved in technical institute education that much of the technician's responsibility could never be expressed in terms of specific day to day functions or job titles.

In sharp contrast to the needs created by the Industrial Revolution with its emphasis on specific job skills, the most significant aspect of technical institute programs today is the constantly increasing need for graduates with broad range abilities who can shift with technological change and assume new responsibilities. In order for a technical institute program to succeed, it must first of all prepare the individual for an entry job in which he can be productive with a minimum of orientation. However, for him then to progress to positions of greater responsibility he must also understand the general range of jobs within his field of technology. One of the strongest characteristics of technical institute programs is the correlation of mathematics and science with technical study. One of the advantages of this approach is that specialized course work may be introduced in the first term. This obviously develops increased student interest and motivation.

While it is not the purpose of this report to discuss the specific problems of technical institute education, the reader might be interested to learn the six broad areas that are in need of further study and work. They are:

1. Program planning and development.
2. Selecting occupations to be studied and making surveys especially in the aerospace industries.
3. Defining occupational areas as distinguished from technician jobs.
4. Identifying the broad national, as well as specific local, needs in engineering technology.
5. Determining the appropriate emphasis on specialized study and curriculum design.
6. Public Relations.

RESULTS

As this report is being published, the first quarter grades have been given. It is very difficult to describe the spirit of both the students and faculty involved in this Program.

Perhaps it could best be described by the following letter which was received by the Chairman of The Richmond Study Group at the end of the first quarter period:

> "Thought you would like to know about my experiences today. As you may know, today was Report Card issuing day. I was being interviewed by a teacher when I saw two of our boys (third-track-group) poke their heads in my doorway. They saw I was busy and turned to go, but I told them to come in anyway.
>
> "Carl and Dale came walking in with pumpkin smiles, about two feet off the floor. They handed me their report cards and back off.
>
> "TWO HONORROLEES! I asked them when they were last on the honor roll. Never!
>
> "Imagine, after eleven years of school, these two boys found success. You never saw two happier boys in all your born days. I'll be expecting other visits from the rest. Eleven of the thirty boys made the honor roll, and I'll bet it's the first time for all of them. When I told them they were in line to attend the scholarship banquet in the Spring, they asked what that was. Imagine being so far removed from academic achievement, in the past, they were unaware of our annual banquet that hosts over 500 students and parents. I sure hope they make it.
>
> "On the debit side, 4 of the boys got D's or F's in U. S. History. This means I get out the old barrel stave and down some sense into their heads.
>
> "I'm looking forward to 50% on the honor roll next quarter. Wish me luck.
>
> William Plutte
> Principal
> De Anza High School."

The results at Harry Ells High School are equally as exciting.